Foreword

National
Oceanic and
Atmospheric
Administration

U.S.
DEPARTMENT
OF
COMMERCE

NOAA Fisheries Service
Northeast Cooperative Research Partners Program

The National Marine Fisheries Service (NOAA Fisheries Service), Northeast Cooperative Research Partners Program (NCRPP) was initiated in 1999. The goals of this program are to enhance the data upon which fishery management decisions are made as well as to improve communication and collaboration among commercial fishery participants, scientists and fishery managers. NOAA Fisheries Service works in close collaboration with the New England Fishery Management Council's Research Steering Committee to set research priorities to meet management information needs.

Fishery management is, by nature, a multiple year endeavor which requires a time series of fishery dependent and independent information. Additionally, there are needs for immediate short-term biological, oceanographic, social, economic and habitat information to help resolve fishery management issues. Thus, the program established two avenues to pursue cooperative research through longer and short-term projects. First, short-term research projects are funded annually through competitive contracts. Second, three longer-term collaborative research projects were developed. These projects include: 1) a pilot study fleet (fishery dependent data); 2) a pilot industry based survey (fishery independent data); and 3) groundfish tagging (stock structure, movements and mixing, and biological data).

> First, a number of short-term research projects have been developed to work primarily on commercial fishing gear modifications, improve selectivity of catch on directed species, reduce bycatch, and study habitat reactions to mobile and fixed fishing gear.
>
> Second, two cooperative research fleets have been established to collect detailed fishery dependent and independent information from commercial fishing vessels. The original concept, developed by the Canadians, referred to these as "sentinel fleets". In the New England groundfish setting it is more appropriate to consider two industry research fleets. A pilot industry-based survey fleet (fishery independent) and a pilot commercial study fleet (fishery dependent) have been developed.
>
> Additionally, extensive tagging programs are being conducted on a number of groundfish species to collect information on migrations and movements of fish, identify localized or subregional stocks, and collect biological and demographic information on these species.

For further information on the Cooperative Research Partners Programs please contact:

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Draft Final Report

DEVELOPMENT OF SPECIES-SPECIFIC ESSENTIAL HABITAT INDICES USING BIOLOGICAL AND HABITAT DATA COLLECTED USING REMOTE SENSING

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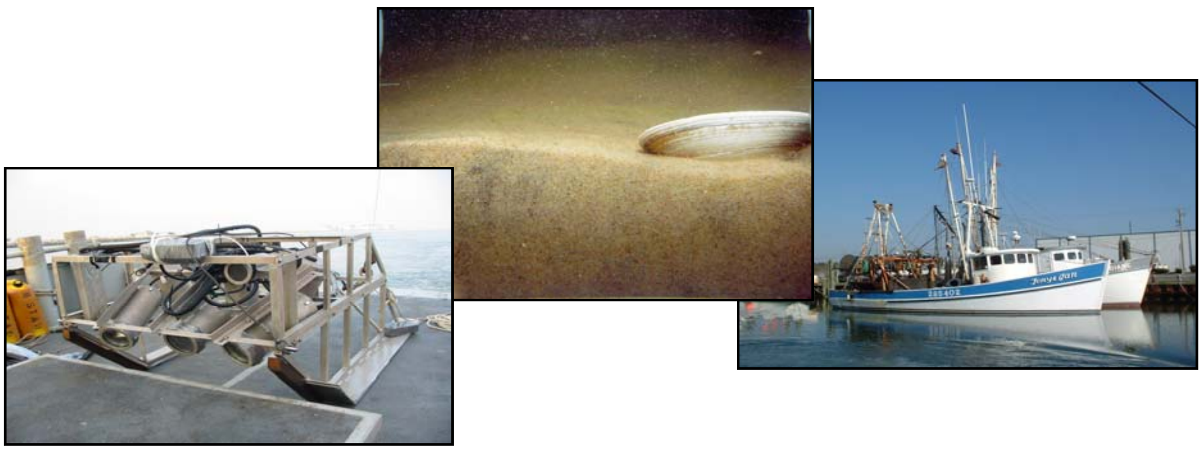

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EXECUTIVE SUMMARY

The habitat requirements of many commercially important fish species must be better understood to adequately manage their populations. One means of identifying habitat variables that may be needed by a particular species is to compare the characteristics of the habitat between areas where the species occurs in high abundance versus low abundance. Because fishermen have obtained this type of knowledge through experience and repeated sampling, they are able to delineate productive versus unproductive habitats within large-scale fishing grounds. The objective of this study was to work in partnership with local commercial fishermen to identify and sample different areas of the near-shore day fishery where summer flounder *Paralichthys dentatus* are typically captured in different abundances, and then use underwater imagery to characterize the benthic habitat and develop an index of essential habitat for summer flounder.

Local commercial fishermen in two fisheries, one in Maryland and the other in Rhode Island, demarcated areas that were productive and unproductive for summer flounder, and then sampled using commercial trawls during summer 2004. Fishermen were effective at determining the relative productivity of different trawling sites within a study area, and captured significantly more fish at sites that they had considered to be productive *a priori*. Their selection of productive and unproductive sites was based on their experiential knowledge gained from years of fishing their local waters. Thus, the different catch rates at productive and unproductive sites within the fishing grounds were due to differences in local habitat characteristics rather than random variation.

One habitat factor considered by fishermen in selecting trawling locations was water depth. Most flounder were captured in depths of 10-20 m, which generally occurred in troughs between shoals in Maryland but along a continuous slope in Rhode Island. However, both high and low catches occurred within this range of depths, and fishermen correctly identified productive versus unproductive habitat within the preferred depth range. These data suggest that one or more habitat characteristics in addition to depth influenced flounder distribution. Our cooperating fishermen were not able to identify microhabitat characteristics that might affect productivity within the fishing grounds.

In this study, we characterized the physical and biological features of the substrate along trawl transects using underwater video and a sediment profiling camera to determine if quantifiable microhabitat characteristics would provide a means of discriminating between the productive and unproductive flounder habitat. A series of generalized linear models were fit to relate habitat variables measured to flounder catch per unit of trawling effort, but no model predicted relative abundance of flounder or site productivity. These negative results appear to be due to the homogeneity in micro-habitat features measured across all sites, whether productive or unproductive. The substrate in both study areas was dominated by sand, but included small amounts of larger particles, shell hash, tubes, and other biogenic structures. The resulting poor association between adult summer flounder abundance and micro-habitat features of the substrate during summer precluded the development of an index of essential fish habitat based on substrate features. We conclude that the abundance of adult summer flounder within the fishing grounds was affected more by meso-scale habitat variables, unmeasured in our study, than by micro-habitat features that could be quantified using the remote sensing technologies employed. However, flounder may have been able to find small areas of preferred micro-habitat features somewhere along trawl transects, even for trawls where different features predominated. Only seven summer flounder were sighted on underwater video, but all were located in fine-sand substrate. Thus, the mismatch in scale of measurement between the trawl and video surveys could also have contributed to the negative results.

We applied the same analytical methods to examine the relation between habitat variables and abundance of a second related species captured during the survey, windowpane flounder *Scophthalmus aquosus*. The spatial pattern of windowpane flounder abundance was similar to that of summer flounder, and was not appreciably related to micro-habitat variables measured. A multivariate analysis examining the relationship of our target species to the community of fish taken in the sample trawls indicated that summer flounder was associated with a community that included clearnose skate, bullnose ray, southern stingray, spotted hake, striped searobin, and scup, in addition to windowpane in Maryland. In Rhode Island the species closely associated with summer flounder were butterfish, scup, winter skate, blue runner, spiny dogfish, bluefish, and windowpane flounder.

It is possible that a large proportion of sandy habitat is a component of the essential fish habitat for summer flounder, but this study suggests that additional habitat features not measured here are important to identify suitable habitat. Our findings indicate that micro-habitat characteristics, such as those that could be quantified using remote sensing, were similar across productive and unproductive sites in both study areas, and thus do not serve as indicators of habitat suitability for the two species we addressed in our analysis, summer and windowpane flounders. As a result, our concept of employing quantitative metrics derived from those characteristics to develop an index of EFH could not be implemented as originally planned. We confirmed that our cooperating commercial fishermen could reliably predict abundance of the target species in various trawling locations, but that the microhabitat features of those locations did not provide a basis for discriminating between the productive and unproductive sites within the general region. The habitat preference of both summer flounder and windowpane appeared to be influenced by one major macro-habitat feature, depth, but to also be influenced by other unmeasured (most likely meso-scale) habitat features that were associated with fixed locations. For example, our cooperating commercial fishermen in Maryland correctly identified productive versus unproductive habitat based on shoal and trough bathymetry. Additional research that measures meso-scale variables such as local current and distribution of prey items may best characterize essential habitat for summer flounder and associated species.

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1.0 INTRODUCTION

Understanding the habitat requirements of demersal fish is essential to conserve and manage their populations because of the role that particular environmental characteristics play in recruitment, growth, and survival. The significance of fish habitat in the management of the nation's fisheries resources is evidenced in the increasing level of scientific (e.g., Benaka 1999) and legislative (Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801, amended 1996; hereafter referred to as the Magnuson-Stevens Act) effort devoted to this issue in recent years. However, mechanistic relationships between fish production and specific habitat features are poorly understood for many species because these links are complex and difficult to study. Habitat requirements may change with life-history stage, migration period, stock abundance, and geographic location (Packer and Hoff 1999; Packer et al. 1999). Another complication is that links between habitat and fish production may be indirect via predators, prey, or other biota that interact with physical habitat features (e.g., reefs; Coen et al. 1999). Because of these difficulties, the habitat variables that limit fish populations at all life stages are unknown for many species. Despite these daunting obstacles, agencies have been required by legislation to define those habitats important to fish using whatever means are currently available.

The National Oceanographic and Atmospheric Administration (NOAA) and regional fisheries councils are required under the Magnuson-Stevens Act to designate and conserve essential fish habitat (EFH) for species under federal management. Essential fish habitat is defined broadly under the act as "those waters and substrate necessary to fish for spawning, breeding, feeding and growth to maturity." Because of the paucity of data available for demersal species in New England and the Middle Atlantic Bight, NOAA has delineated EFH using abundance data from fishery-independent trawl surveys (Reid et al. 1999) rather than specific habitat criteria. Trawl data are used to define EFH for relatively large geographic areas (i.e., ten-min latitude and longitude squares) where, on average, the species has been captured commonly. The underlying assumption of this approach is that density of a species, as reflected in trawl catch-per-unit-effort, is related to habitat quality for that species. This approach sometimes results in nearly the entire range of the species being listed as EFH, and thus encompassing very large geographical areas. While assigning large areas as EFH is protective of a species, it does not contribute to the identification and conservation of specific habitats that may be of particular importance to a species on smaller scales. Such information is of particular importance when potential for impacts from man-induced habitat alterations, such as off-shore drilling or mining, must be addressed. At issue is how information of this nature can be acquired in a cost effective manner and be generally applicable over broad expanses of a species' range.

Commercial fishermen are clearly aware of locations in which they can reliably harvest sought after species on a regular basis. Such knowledge is generally based on years of fishing experience and is essential to ensure the financial viability of their fishing ventures. Such knowledge and experience can thus serve as a valuable resource for designing and conducting fisheries research (Haggan et al. 2001). To better utilize the knowledge of commercial fishermen through collaboration with scientists and fishery managers, the Cooperative Research Partners

Initiative (CRPI) was established by the Northeast Regional Office of NOAA Fisheries in 1999. The CRPI encourages researchers to partner with commercial fishermen to develop studies and collect data such as those needed to characterize EFH. Versar, Inc. responded to a Broad Agency Announcement from the CRPI and proposed to investigate the feasibility of developing, in cooperation with commercial fishermen, a quantitative index that could be used for detailed mapping of species-specific EFH in a manner acceptable to fisheries scientists, fisheries managers, and the fisheries industry and on a smaller scale than that developed by NOAA using the fishery-independent trawl data. In our project, we proposed to employ local commercial fishermen to identify a series of study sites known to the commercial trawl fishery as good or poor sites for the target species within the fishing grounds. We then proposed to map the physical and biological features of the seafloor bottom at the study sites concurrently with or subsequent to normal bottom trawling by our commercial fishermen team members. The catch per unit effort (CPUE), a measure of the relative density of the target species, would then be used as evidence of the suitability of the habitat for individual species. The micro-habitat and biological community variables documented and quantified at each of the sites would then provide the variables to be used in EFH index development.

In this study, we sought to identify habitat characteristics that could serve as reliable predictors of relative abundance of fish species by establishing the characteristics of sites with high abundance of a species and characteristics of locations where the same species was in low abundance, and then systematically identifying the specific characteristics that differ between the sites. Data from fishery-independent trawl surveys, such as that used by NOAA, are useful for this type of analysis but not ideal because trawl samples are collected at random locations within relatively large spatial strata. The random sampling is necessary to obtain unbiased abundance estimates for stock assessment, but resulting samples may be less useful for analyses related to habitat because they encompass large random variation across the continuum of habitat conditions measured. Differences in habitat condition can be identified and statistically quantified more easily if habitats sampled are stratified *a priori* into sites of high versus low abundance. We believed that commercial fishermen would be particularly aware of differences in fish abundance within traditional fishing grounds and could thus provide the information for achieving this type of stratification (e.g., Pederson and Hall-Arber 1999; Williams and Bax 2001).

Determining habitat characteristics on a small but meaningful scale poses a challenge due to the potential expense of collecting the type of data that must be incorporated into a characterization over large areas. We determined that remote-sensing devices, such as oceanographic cameras and multi-beam sonar, provide a realistic means of characterizing benthic habitat because they can accurately and non-destructively map small-scale features of the habitat over large areas. Recent literature has demonstrated that habitat characteristics collected using cameras (Wright et al. 2000; Diaz et al. 2003) and other remote sensors (Auster 2001; Zajac et al. 2003; Hewitt et al. 2004) are useful to elucidate important species-habitat relationships. We characterized habitat in local areas of high and low fish abundance within fishing grounds, as determined by participating fishermen, using an underwater camera and a sediment-profiling camera that collected subsurface images of the sediment. We conducted extensive exploratory analysis to investigate habitat characteristics, at both the micro- and macro scale that could be used to reliably predict high or low abundances of our target fish species and that might prove useful in the development of a viable species-specific EFH index. In this report, we describe the details of our study, present data collected, describe our analytical approaches and results, and discuss implications of our findings for new approaches to defining EFH.

2.0 METHODS

2.1 STUDY DESIGN

The original intent of this project was to select two target species that exhibited different (somewhat mutually exclusive) habitat preferences, and to limit the field study to fishing grounds in the Mid-Atlantic region only, employing as partners commercial fishermen working out of Ocean City, Maryland. In negotiations with CPRI, a number of modifications were made to our original proposal prior to contract award within the initial proposed budget. A major modification was the expansion of the sampling program to also include fishing areas in Southern New England and to extend the level of participation by commercial fisherman in our project. The need to recruit commercial fishery cooperators in a new area necessitated a number of additional modifications to the program. First, we redesigned the study to focus on one species in both regions. After reviewing several data sets, including the NMFS trawl data, and after discussions with our group of fishermen, we concluded that it was not feasible to study two separate species in two regions with same level of effort as originally proposed for the Maryland study. Subsequent logistical obstacles resulted in further discussion with CPRI and consequent additional design revisions, including the contracting of commercial fishermen that operated on near-shore fishing grounds during summer. By focusing on a single species distributed near-shore we were able to maintain comparable data collection efforts in both regions because we could utilize smaller fishing vessels that participate in the day fishery. This design also allowed the comparisons of habitat preferences between regions. Although we did not design our study specifically to collect data for two species for reasons stated above, we analyzed data for a secondary species associated with the target that showed similar habitat preferences.

We selected the summer flounder (*Paralichthys dentatus*) as the primary target species to test the relationship between benthic habitat variables and abundance for use in an index of EFH. The summer flounder or fluke is a managed species that supports important commercial and recreational fisheries. Habitat needs of juveniles have been quantified relatively well (cf., Packer and Hoff 1999), but little specific habitat information is available for adult life stages. Summer flounder range from Nova Scotia to Florida and are most abundant in the Middle Atlantic Bight. Summer flounder occur along the inner and outer continental shelf and within shallow estuarine waters. Although summer flounder exhibit seasonal and latitudinal migrations (Kraus and Musick 2003), adults are commonly captured on the inner shelf by commercial trawlers in the near-shore day fishery during the summer. Because the species is a flatfish, it is strongly associated with the benthic zone and, thus, likely to prefer measurable habitat characteristics of the substrate.

We also examined the relation between habitat and the abundance of a related species, the windowpane flounder (*Scophthalmus aquosus*). Although participating fishermen did not explicitly target them, we tested the relation for another species to determine the extent to which EFH models might be applicable to families of related fishes with similar habitat preferences. The windowpane flounder or sand flounder is another commercially managed flatfish species with a similar range as summer flounder, from the Gulf of St. Lawrence to Florida. Windowpane flounder exhibit seasonal spawning migrations but are captured throughout the year in New England and the Middle Atlantic bight. They are abundant from near shore to depths of about 56 m (Morse and Able 1995), and are commonly captured by fishermen targeting summer flounder.

Following modifications to the scope of the project as described above, two study areas in the Middle Atlantic Bight on the inner continental shelf were selected by a participating local fisherman that fished in these areas. Fishermen chose locations where they typically captured summer flounder during the summer months, but which were large enough to include areas where the fishery had historically been both productive and unproductive. The first area was located offshore of Ocean City, Maryland. The length of the area was approximately 20 km perpendicular to the shoreline, and it extended from the shoreline to approximately 30 km offshore. Depth ranged from approximately 5 to 19 m. The second area was located offshore of Point Judith, Rhode Island. The length of the area perpendicular to the shoreline was approximately 55 km, and extended from just offshore out to approximately 45 km, including Block Island. Water depth in the Rhode Island area ranged from approximately 9 to 28 m. Fishermen used National Ocean Service navigational charts to delineate areas within each area that they predicted to be productive for summer flounder fishing and nearby sites that they predicted to be unproductive (hereafter referred to as productive and unproductive areas) based on their professional judgment, past experience, and previous sampling of the area.

2.2 TRAWL DATA COLLECTION

Trawl samples were collected using two stern-trawling commercial fishing vessels. Sampling effort was divided approximately evenly between defined productive and unproductive sites to capture a range of flounder abundance and, presumably, to sample a corresponding range of habitat structure. To avoid trawling over multiple habitats typical of normal commercial trawling operations, all trawl samples were restricted to approximately 15 minute tows at constant speed of approximately 3 knots. Trawl location data was recorded along the entire trawl line using data logging software connected to a shipboard differential global positioning system (DGPS). After a trawl was completed, all fish captured were identified to species and enumerated. Twenty-five individuals from each species were also measured to the nearest mm. The mean depth of each trawl was estimated using National Geophysical Data Center bathymetric maps (NGDC 2005). A subsample of depth measurements was made directly along trawls sampled with the video camera in Rhode Island to check concordance with the bathymetric data. These data agreed closely with the map data (mean difference 0.9 m).

In Maryland, sampling was conducted by the 16.8-m F/V *Tony and Jan* using a standard two-seam flounder trawl with an 18.3-m headrope and 24.4-m footrope. The net consisted of 14-cm stretched mesh polypropylene throughout and was equipped with chafing gear on the cod-end bag. A total of 56 trawls were conducted between 16 June and 31 June, 2004. Twenty-six trawls were in productive areas, and 30 trawls were in unproductive areas.

In Rhode Island, sampling was conducted by the 17-m F/V *Grandville Davis* using a standard 2-seam flounder trawl with a 15.8-m head rope and 21.3-m footrope. The net consisted of 15.2-cm stretched mesh polypropylene throughout and was equipped with chafing gear on the cod-end bag. To avoid hangs on the bottom this net was also equipped with large rubber 25.4-cm disks called "rock hoppers" attached to the center of the lead line. A total of 50 trawls were conducted between 2 August and 6 August. Twenty-four trawls were in productive areas, and 26 trawls were in unproductive areas.

2.3 REMOTE SENSING DATA COLLECTION

We used underwater video and a sediment profile cameras to characterize benthic habitat along the trawl lines. An underwater video sled equipped with forward and downward facing digital video cameras (Panasonic model GP-KR222) and was towed between 2 and 3 knots on the bottom along the path of fish trawls. To reduce the effects of turbidity, the sled was equipped with video strobes (Perkin-Elmer model MVS-5004). The forward facing camera was mounted 0.2 m off the bottom at an oblique angle of 20^o to provide a close-up view of bottom morphology and to detect the presence of biological features from 0.5 to 2.0 m^2 in front of the sled. The downward facing camera was mounted perpendicular to the bottom at a distance 0.15 m from the sediment surface with a field of view of 588 cm^2. The information collected from the cameras was recorded onto digital videotape with georeferenced data superimposed on the video using an onboard DGPS so that habitat from specific trawl lines could be identified in later analysis. The Maryland survey was conducted from the 16-m fishing vessel North Star between 20 July and 24 September 2004. The Rhode Island survey was conducted from the *F/V Captain Roberts* between 4 and 8 October 2004.

Benthic habitat was characterized from the underwater video by analyzing images from recorded videotape using an editing deck and high-resolution video monitor. Images were analyzed at each 2 min interval of towing with the video sled. If video images were not visible at the 2-minute interval, because of poor near-bottom visibility, images from the last instance the bottom was visible and the first moment the bottom reappeared were analyzed. For analysis and archiving, 20-second video clips were captured around the sampled videotape times using Apple program iMove. Each video sample from the forward camera was 2 to 4 m^2, depending on turbidity levels, and 0.25 m^2 for the down camera. All fish and megafauna observed were identified to the lowest possible taxon, and physical and biological features of the benthic habitats at the instance the fish was noted were recorded. For each image, the substrate was classified for the presence or absence of physical and biological characteristics related to bottom relief, substrate particle size, biogenic structures, and shell hash (Table 1). The classification system was similar to that described by Diaz et al. (2003). Broad-scale data on substrate and surface characteristics were collected on 41 of 56 trawl lines in Maryland and 46 of 50 in Rhode Island using the video sled. Excessive turbidity or other logistical reasons prevented collection of data on all trawls.

Small-scale surface and sub-surface sediment information from trawl lines was collected using a digital sediment profile camera. Sediment profile images (SPI) were used to characterize benthic habitat similarly to the video images. The sediment profile camera works like an inverted periscope, taking cross-section images of the upper 20 to 30 cm of the seafloor (cf, Rhoads and Cande 1971). The SPI camera used a Minolta Dimage-7i 5.2-megapixel digital camera. The camera was set to ISO 200, white balance to flash color temperature, contrast to normal, saturation to normal, maximum image size of 2560x1920, and saved using super-fine jgp compression. A video feed from the digital camera to the surface vessel allowed monitoring of the profile camera operation in real time. The camera was triggered from the surface about 1-sec after bottom contact and after the prism stopped penetrating the sediment. Approximately 50 to 75 kg of lead were added to the camera frame to improve prism penetration.

Due to poor weather conditions during planned field data collections, the original intent of collecting SPI data from all trawl tracks had to be abandoned. In order to generate image data that we could employ to characterize productive and unproductive sites we implemented a representative sampling scheme. A subset of 14 trawls in Maryland and 13 trawls in Rhode Island were sampled using SPI. Trawls sampled were selected by categorizing the catch of summer flounder into groups of low, medium, or high. Then trawls were randomly selected from the high and low abundance categories to capture the greatest range of habitat characteristics hypothesized to be related to flounder abundance. A total of 6 high-abundance and 7 low-abundance trawls were profiled for Maryland, and 6 high-abundance and 6 low-abundance trawls were profiled for Rhode Island. Within each trawl, 10 profiles were collected from the beginning, middle, and end for a total of 30 images per trawl line. For each sample, a set of characteristics related to substrate size and composition, physical morphology, and biota were measured as described in Table 2.

2.4 DATA ANALYSIS

We modeled the relation between flounder CPUE in trawls and habitat variables measured using the underwater camera or SPI by fitting a set of generalized linear models, and then using a model selection procedure to determine which habitat variables were the best predictors of flounder abundance. In taking this approach, we were not assuming necessarily that the habitat variables we measured were causative factors in any predictive relationship established. Any variable found to be of predictive value might itself be an indicator of some other environmental condition or feature not measured in our program. Although multiple points were sampled along a trawl line using the underwater video and sediment profile cameras, flounder were captured at unknown positions within a trawl transect, and allowed for only a single CPUE response for each habitat variable. Therefore, habitat variables measured at individual points along a trawl were consolidated into a single mean or proportion for each trawl. Variables were reduced by taking the proportion of individual samples for variables that were binary, or the mean for variables that were counts (Tables 1 and 2). The number of summer flounder captured per trawl tow was standardized to catch per unit of effort (CPUE) defined as the number of fish captured per 1,000 m of trawl distance. The data were transformed to $\log_e$(CPUE + 1) to stabilize the variance among catches and to reduce or eliminate the dependence between mean CPUE and the variance, thus supporting standard assumptions for the statistical analysis. For each study area, the success of participating fishermen at predicting productive versus unproductive areas for summer flounder was evaluated using a two-sample *t*-test with $\log_e$(CPUE + 1) as the response variable and trawl designation as productive or unproductive as the explanatory variable. No statistical analysis such as logistic regressions were performed to link flounder observations on underwater video with micro-habitat observations because only seven flounders were encountered in the 1,030 video image frames analyzed, and all were observed in the same habitat (sand).

The proportions or means of habitat variables across all images along the trawl tracks were tested for a relationship with summer flounder abundance by fitting a set of generalized linear models with $\log_e$ flounder (CPUE + 1) as the dependent variable and one or more habitat variables as predictors. We then evaluated the relative evidence for habitat variables as predictors of abundance using Akaike's Information Criteria corrected for small sample size (AIC_c, Hurvich and Tsai 1989; Burnham and Anderson 2002). This procedure evaluates the weight of evidence for each model relative to other models in the set. Rankings are based on model fits as measured by the log-likelihood, and parsimony as measured by the number of parameters estimated. The relative evidence for a model can be summarized by its Akaike weight (w_i), a proportion summing to one for all models in the set. Model-averaged means and associated 95% confidence intervals were calculated for all habitat predictors in a set of models to judge their unconditional effect sizes. That is, effect estimates were averages weighted by the relative evidence of support for each model. The weighted estimates were therefore more likely to reflect true effects than estimates that were conditional on a single model (cf., Burnham and Anderson 2002).

Because we measured a large number of benthic habitat variables, some of which were confounded or hierarchical, we developed a set of models to link habitat variables to EFH interactively. Models consisting of single variables listed in Table 1 were fit for an initial run. Additional models that included multiple variables and interactions were added including only those that held more than 10% of the w_i in the initial run, or the two variables with the greatest w_i. For variables that were hierarchical (e.g., bedform size, shape, and sharpness describe types of bedforms), the general variable (i.e., presence of bedforms) and additional models were fit to nested subvariables. A few variables were also correlated by definition. For example, the biogenic variable incorporated tubes, burrows, and other sessile life forms. Correlated variables were never included in the same model. Because the interactive approach taken here may lead to over-fitting of models and conservative precision estimates (Burnham and Anderson 2002), we considered models obtained from this procedure to be preliminary and subject to further investigation using other data sets.

We performed an additional analysis using the underwater video habitat data as described above. Logistic models were fit using productive versus unproductive trawls as determined *a priori* by the fishermen as the response variable rather than observed CPUE. This analysis was performed because the fishermen's designations as productive or unproductive could be viewed as the result of long-term sampling that might better reflect EFH features associated with fixed locations than the result of a single sample in time such as our trawl data.

An additional multivariate analysis was carried out identify the fish species that were closely associated with summer flounder in the habitats sampled, using the PRIMER v.5 statistical package (Clarke and Gorley 2001). For the group of all fish species captured, the SIMPER procedure was used to estimate similarity percentages. This analysis identifies which species contribute most to the average dissimilarity between groups of samples, and which species contribute more consistently, by examining the ratio of the average dissimilarity contribution of each species to its standard deviation. Two analyses were run using this procedure. First, trawl samples were classified into two summer flounder abundance groups as low (<3.5) and high (>3.5). Second, samples were classified by whether trawls occurred in productive or unproductive areas identified by the fishermen.

3.0 RESULTS

Summer flounder catch among trawls in both states ranged from 0 to about 20 fish per 1,000 m (Figure 1; Table A-1). Fishermen in both Maryland and Rhode Island were effective at identifying sites within the study area that resulted in high versus low flounder capture rates (Figure 2). In Maryland, flounder catch was greater in productive areas than in unproductive areas, with mean difference of 1.22 for $\log_e$(CPUE + 1)-transformed units (95% CI, 0.89 to 1.54, t = 7.55, df = 53), corresponding to about 2.37 more fish/1,000 m captured in productive areas (95% CI, 1.44 to 3.66). In Rhode Island, flounder catch was greater in productive areas by 1.35 $\log_e$(CPUE + 1)-transformed units (95% CI, 0.98 to 1.73, t = 7.35, df = 44), corresponding to about 2.87 more fish/1,000 m captured in productive areas (95% CI, 1.67 to 4.61). Catch of summer flounder was greater for every size class captured in productive areas than in unproductive areas, but the distribution of sizes was generally similar (Figure 3). An exception was that relatively large (> 55 cm) summer flounder were only captured in productive areas.

Trawls designated as productive or unproductive for summer flounder also corresponded to the number of windowpane flounder captured (Figure 4). Windowpane catch in Maryland was greater in productive areas by 0.19 transformed CPUE units (95% CI, 0.08 to 0.29, t=3.40, df=53), or 0.21 fish/1,000 m (95% CI, 0.08 to 0.34). In Rhode Island, catch was greater in productive areas by 0.34 transformed CPUE units (95% CI, 0.22 to 0.46, t = 5.77, df = 44), or 0.40 fish/1,000 m (95% CI, 0.25 to 0.58).

Relative abundance of summer flounder, as measured by the CPUE, was generally related to mean depth of trawls. Most flounder were captured in the range of 10-20 m depth (Figures 5 and 6), but both high and low catches occurred within that range. In Maryland, depths in this range were generally located at the bottom of troughs between shoals, and represented some of the deepest habitat available. We explored the value of depth profile characteristics perpendicular to the trawl track as a meso-habitat indicator of habitat suitability based on this observation. However, we were unable to establish a consistent metric that would be representative of this habitat feature and that could be statistically linked to the level of flounder catch. Also, this type of shoal and trough habitat did not occur in the Rhode Island sampling area and thus a metric of this nature would not have been applicable there. In Rhode Island, most of the substrate in the 10-20-m depth range was located near the shoreline, and much of the study area consisted of deeper water (Figure 1). Even when trawls were located in the 10-20-m depth range, fishermen correctly identified most of the unproductive trawl sites for summer flounder (Figure 5). The bottom micro-habitat at sites designated as productive and unproductive were similar both in Maryland and Rhode Island, and dominated by fine sand. For example, 75% (SE=2%) of the total trawl track in productive areas in Maryland were in fine sand with no shells or cobbles, as compared to 83% (SE=3%) for unproductive areas. In Rhode Island, 82% (SE=3%) of the trawl track in productive areas were on fine-sand, as compared to 81% (SE=3%) for unproductive areas. The 95% confidence limits for differences in the proportion of sandy habitat in productive versus unproductive areas overlapped zero, and thus the hypothesis of equal amount of sandy habitat between the areas could not be rejected at the 5% level (cf. Schenker and Gentleman 2001). These data suggest that one or more unmeasured variables related to fixed habitat also influenced summer flounder distribution within the preferred range of depths. For windowpane flounder, the distribution of productive and unproductive sites with respect to depth was similar to that of summer flounder (Figure 6).

Summer flounder observed directly in video camera samples used a single type of benthic substrate consistently but few observations were made. We observed a total of 7 summer flounder in both study areas in video camera samples. All were located in sample frames with substrate composed of 100% fine sand. No windowpane flounder were observed in video camera samples.

Benthic habitat variables measured using the underwater video camera did not predict CPUE of flounder well. Flounder catch was best predicted by a model that included two variables – the proportion of samples that were composed completely of sand, and the mean number of burrows per sample (Table 3). Two other models were plausible, as indicated by their

Akaike weights of about 0.25. The first included the same variables as the best model plus an interaction term. The second consisted of sediment only (and an intercept). However, the adjusted R^2 for the best model was only 0.02, indicating that it had little predictive ability. Furthermore, 95% confidence intervals on all model-averaged parameter estimates were nearly centered on zero (Table 4), indicating that no benthic substrate factor included in our analysis consistently explained CPUE of summer flounder in trawls. Models fit for windowpane flounder similarly lacked explanatory power. Models that included burrows and tubes fit best (Table 5), but parameter estimates intersected zero for all variables tested (Table 6).

Habitat characteristics measured using the sediment-profiling camera were also generally poor predictors of flounder abundance in trawls because of the similarity in micro-habitat across productive and productive areas. The best predictor of flounder CPUE was the mean number of burrows present per sample (Table 7). The adjusted R^2 of this model was 0.28, but the Akaike weight for this model was only 0.21, indicating that there was considerable evidence for other models given the data. A number of other models had Akaike weights in the range of 0.05 to 0.19, providing some support for each of them. Confidence intervals on the model-averaged estimates of effect size all included zero (Table 6), indicating that none of the variables explained variation in flounder CPUE well, as described above. Analysis of the SPI data using CPUE of windowpane flounder as the response variable also provided some evidence for a linkage between habitat characteristics and CPUE (Table 9). Model-averaged estimates indicated that oxic voids were positively related to windowpane flounder abundance (Table 10), but this was primarily because an outlying data point had a large influence on the analysis.

Logistic models fit to estimate the likelihood of productive versus unproductive areas as a function of habitat variables also performed poorly. The global model containing all single variables in the set held about 80% of the weight of evidence (Table 11), but no habitat variable measured could be used to predict the productivity of a site with 95% confidence (Table 12).

Multivariate analysis indicated that the species best discriminating (i.e., more consistently) between the low and the high summer flounder abundance groups in Maryland were bullnose ray, windowpane, and spotted hake (Table 13). Summer flounder were, by definition, most closely associated with their abundance groupings. Summer flounder, clearnose skate, bullnose ray, southern stingray, spotted hake, striped searobin, scup, and windowpane, contributed to 69% of the dissimilarity between the low and the high summer flounder abundance groups. In Rhode Island, species best discriminating between the low and the high summer flounder abundance groups were windowpane and winter skate. Butterfish, summer flounder, scup, winter skate, windowpane, blue runner, spiny dogfish, and bluefish contributed to 67% of the dissimilarity between the groups. In both states, the analysis was very similar for samples classified as productive or unproductive (Table 14).

4.0 DISCUSSION

The objective of our study was to determine if some type of index, derived from habitat variables that could be mapped accurately by remote sensing, could be developed and used to characterize Essential Fish Habitat for specific species on relatively small geographical scales. Our approach was dependent on and confirmed the assumption that our cooperating commercial fishermen, based on their experience in fishing their local waters, could reliably predict higher abundances of our target species in some specific locations than in others. However, we found that micro-habitat features at the fishermen-selected locations, of the type that could be quantified using the remote sensing technologies employed in this study, were similar between productive and unproductive areas, and thus had little ability to discriminate between the suitability of the locations for our target species. It is possible that a large proportion of sandy habitat is a component of the essential fish habitat for summer flounder, but this study suggests that additional habitat features not measured here are important to identify suitable habitat.

The fishermen that partnered with us on this study correctly and consistently identified productive and unproductive areas for summer flounder and windowpane (Figures 2, 3 and 4). From our discussions with the fishermen, a macro-habitat feature, depth, was a major factor in their selection of trawling locations. The depth range where most summer flounder were captured in this study agrees closely with data reported elsewhere in New England and the Middle Atlantic Bight. Most adult summer flounder captured in fishery-independent surveys between 1963 and 1997 were in 10-20 m depths during summer (Packer et al. 1999). However, summer flounder are commonly captured in deeper water as they migrate offshore during spring and winter (Packer 1999; Packer and Hoff 1999). Participating fishermen also stated that they would not have fished in the areas that they did during other seasons. These results underscore the importance of considering a species' life stage, migratory patterns, and season when investigating the affinity of the species for various habitat characteristics (Langton et al. 1996).

While depth was a significant factor in selection of trawling location by our fishermen, their past history of fishing success or lack there of at various locations over the course of their fishing careers was of even greater relevance. Such knowledge and expertise has often been underutilized in designing and interpreting fisheries studies (Pederson and Hall-Arber 1999; Ames 2001), but is increasingly being called upon to develop and carry out all aspects of research on managed species (Haggan et al. 2001). The correct classification by our fishermen of locations for trawling as productive or unproductive even within the preferred range of depths and similar micro-habitat indicated that other habitat features that were not explicitly measured by remote sensing or defined by the fishermen were also important. In Maryland, fishermen commonly target summer flounder in troughs between shoals during the summer (Jeff Eustler, commercial fisherman, personal communication). We noted earlier that we were unsuccessful in attempting to develop a metric that we could employ to include this meso-scale feature of bottom topography in our index development effort. Also, because similar shoal and trough habitat was rare in the Rhode Island study area, a metric of this nature would not have been applicable throughout the range of the summer flounder, and could not contribute to achievement of our study objective. The shoal-trough bathymetry pattern in the Mid-Atlantic area may be a proxy for other important meso-scale habitat features such as appropriate current or availability of prey items. Given the lack of association between flounder abundance and microscale physical and biological substrate features measured here, these meso-scale habitat variables merit further investigation to identify the important features that could be consistently related to productivity in sites identified by the fishermen.

The similarity in micro-habitat across sites within each study area resulted in a lack of correlation between flounder CPUE in trawls and any of the many micro-habitat variables that we were able to quantify in this study. This lack of discrimination between suitable and unsuitable habitat precluded the development of an EFH index for adult summer flounder during the summer. There are other plausible explanations for the absence of relationships between fish abundance and the measured micro-habitat variables. In general, the benthic habitat requirements of adult fishes become less specific as they mature and migrate (Able and Fahay 1998, Steves et al. 1998). Juvenile fishes frequently require specific meso- and micro-scale habitats (Sullivan et al. 2000), and their abundance has been linked to benthic habitat variables using similar remote sensing techniques to those described here (Diaz et al. 2003). The negative results of our analyses suggest not only that such relationships do not exist with adult life stages of at least the two species we considered, but also that the micro-habitat features are not surrogates for any other unmonitored environmental features that might be important for the adult life stages. As suggested by the importance of the shoal-trough bathymetry, adult summer- and windowpane-flounder distributions are likely to be influenced by unmeasured meso-scale habitat variables that were not documented in the study.

One factor that could have contributed to our inability to link fish abundance to micro-habitat features was that some information was lost by coupling trawl data with video observations. Fish were captured in trawls at unknown locations along the transect and could conceivably have shown specific preferences for certain micro-habitat features at the specific location where they were captured. Images from underwater camera recordings offered the potential for examining affinity of adult summer flounder for specific micro habitat characteristics at a scale smaller than the length of a trawl. However, only seven flounder were observed in all of the video images recorded, all on fine sand bottom. The small number of flounder observed was a function of the relatively narrow field of view of the device employed in this study. The problem of small sample sizes when using remote sensing methods is a common one, so remote-sensing data are often paired with trawling to increase sample size, as we have done here (Auster et al. 1995). If we had encountered substantially more flounders in the images from the video recording, a model that used video observations might have allowed us to better elucidate micro-habitat preferences. Our results demonstrate that coupling methods in this way may represent a trade-off between sample size and measurement precision when sampling methods have different spatial resolutions.

The result that flounder sighted on video were located in fine sand agrees with published literature linking flatfish in general (Gibson 1997), and juvenile summer flounder (reviewed by

Packer and Hoff 1999) to sandy, soft-bottom habitats. However, we did not obtain similar results when comparing video images to trawl data. This was probably because sandy substrates or other types of preferred habitat were available to flounder somewhere within the length of each tow, even if a particular habitat did not predominate in our video samples. The problem could have been exacerbated if flounder selected patchy habitats. For example, Lascara (1981; *cited in* Packer and Hoff 1999) found that summer flounder selected sandy substrates adjacent to eelgrass patches, presumably so that they could conceal themselves but also ambush prey easily.

The similarity in distributions of summer flounder, windowpane flounder, and other species described in the multivariate analysis indicates that habitat features influencing adult summer flounder abundance during the summer were also important for a larger community. This result suggests that, in some cases, fishermen may be able to provide more information related to EFH than they are explicitly asked for. Obtaining this type of information from fishermen may be the only way to efficiently study EFH requirements for the large number of species managed, each with potentially different needs by life stage, season, region, and migrational period. If additional studies such as this one can identify essential-habitat characteristics for managed species and recognize variables that are less important, then resources can be better directed toward effective management techniques within well-defined areas to conserve important stocks.

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Table 1. Habitat characteristics measured at points along trawl lines using underwater video images. All variables had a binary response (e.g., yes or no) except burrows, tubes, and biogenics, which were counts.

Physical
- Bedforms – were bedforms present? If yes:
  - Bedform size – was the local bedform relief > 30 cm in wavelength?
  - Bedform shape – was the local bedform asymmetric?
  - Bedform ripples – were bedform ripples present?
  - Bedform sharpness – was the bedform crest sharp?
- Sediment – did the sample consist entirely of course sand or finer sediment (≤1 mm)?[1]

Biological and Biogenic
- Shell hash (5%) – was >5% of the area occupied by shell fragments?[2]
- Shell hash (25%) – was >25% of the area occupied by shell fragments?
- Whole shells – were whole shells present?[1]
- Tubes – number of tubes present (*Diopatra*, etc)?
- Burrows – number of burrows present.
- Biogenics – number of burrows, tubes, feeding pits, or other sessile fauna present.

[1] Substrate particle sizes were initially categorized as silt or clay, fine sand, medium sand, course sand (<1 mm), granule (1-4 mm), pebble (4-64 mm), or cobble (64-256 mm; Table A-2), but categories were aggregated to create a binary variable because most samples consisted completely of sand, and the occurrence of larger particles was rare

[2] These variables were tested but do not appear in the final model results because they had Akaike weights < 0.01 indicating that they had essentially no support.

Table 2. Habitat characteristics measured at points along trawl lines using a sediment profile camera. All variables had a binary response (e.g., yes or no) except burrows, large tubes, small tubes, and infauna, which were counts.

Physical

- Bedforms – were bedforms present?
- Maximum grain size – were the largest particles >1 mm (course sand)?
- Dark minerals – were dark minerals present
- Clasts/mounds – were clasts or mounds present?

Biological

- Infauna – were benthic infauna present?

Biogenic

- Burrows – number of burrows present
- Pellets – were animal fecal pellets present?
- Large tubes – number of large tubes present (*Diopatra*, etc)?
- Small tubes – number of small tubes present?

Table 3. Models used to compare flounder abundance (transformed CPUE) along trawl lines to habitat variables measured with the underwater video camera. All models included an intercept. Variables enclosed in parentheses were nested within the variable listed to the left. Log likelihood is the value of the maximized log-likelihood function, k is the number of parameters estimated in the model (including the intercept and mean-square error), AIC_c is Akaike's Information Criterion corrected for small sample size, Δ_i is the difference between the model with the lowest AIC_c and the given model, and w_i is the Akaike weight for the model indicating the evidence for the model relative to others in the set.

Model	Log likelihood	k	AIC_c	Δ_i	w_i
All variables listed + intercept (no interactions)	-97.023	9	214.545	0.000	0.416
Sediment[1] + Burrows	-103.431	4	215.382	0.837	0.274
Sediment + Burrows + Sediment*Burrows	-102.938	5	216.666	2.121	0.144
Sediment	-105.245	3	216.798	2.253	0.135
Burrows	-108.027	3	222.347	7.802	0.008
Bedforms(Bedform ripples)	-107.048	4	222.590	8.045	0.007
Bedforms(Bedform size)	-107.764	4	224.021	9.476	0.004
Tubes	-108.916	3	224.124	9.578	0.003
Biogenic structure[2]	-109.436	3	225.165	10.620	0.002
Bedforms	-109.485	3	225.262	10.716	0.002
Shell hash (25-75%)[3]	-109.506	3	225.304	10.759	0.002
Bedforms(Bedform sharpness + size + shape + ripples)	-105.973	7	227.381	12.836	0.001
bedforms(Bedform shape)	-109.472	4	227.438	12.893	0.001
Bedforms(Bedform sharpness)	-109.485	4	227.463	12.918	0.001
Intercept only	-137.527	2	279.170	64.624	0.000
State (block)	-137.431	3	281.098	66.553	0.000

[1] Proportion of samples that were completely composed of course sand or finer sediment (≤ 1 mm).
[2] Biogenic structure was the presence of burrows, tubes, or other sessile life forms.
[3] Proportion of samples where shell hash covered 25-75% of the area.

Table 4. Model-averaged estimates of effect size and approximate 95% confidence intervals for variables used to predict flounder abundance along trawl lines with the underwater video camera. All confidence intervals intersect 0, indicating that all variables were poor predictors of flounder abundance. Estimates were calculated using all models listed in Table 3 and included a 0 for variables not present in a particular model (Burnham and Anderson 2002).

Variable	Mean parameter estimate	95% Confidence interval	
		Lower	Upper
Sediment	-0.112	-1.380	1.156
Burrows	-0.016	-0.679	0.647
Tubes	-0.009	-0.560	0.542
Biogenic structure	0.012	-0.525	0.549
Bedforms	0.071	-1.123	1.264
Shell hash (25-75%)	0.040	-1.070	1.150
State (block)	0.058	-0.992	1.107

Table 5. Models used to compare windowpane abundance (transformed CPUE) along trawl lines to habitat variables measured with the underwater video camera. All models included an intercept. Log likelihood is the value of the maximized log-likelihood function, k is the number of parameters estimated in the model (including the intercept and mean-square error), AIC_c is Akaike's Information Criterion corrected for small sample size, Δ_i is the difference between the model with the lowest AIC_c and the given model, and w_i is the Akaike weight for the model indicating the evidence for the model relative to others in the set.

Model	Log likelihood	k	AIC_c	Δ_i	w_i
Burrows + Tubes	7.404	4	-6.314	0.000	0.409
Burrows	6.212	3	-6.130	0.183	0.373
Tubes + Burrows + Tubes*Burrows	7.426	5	-4.102	2.211	0.135
Intercept only	2.239	2	-0.361	5.953	0.021
Tubes	3.090	3	0.114	6.427	0.016
State (block)	2.632	3	0.972	7.286	0.011
Bedforms	2.619	3	1.055	7.369	0.010
Biogenic structure	2.439	3	1.415	7.729	0.009
Shell hash (25-75%)	2.331	3	1.630	7.944	0.008
All variables listed + intercept (no interactions)	8.928	9	2.644	8.958	0.005
Sediment	1.323	3	3.661	9.975	0.003

Table 6. Model-averaged estimates of effect size and approximate 95% confidence intervals for variables used to predict windowpane abundance along trawl lines with the underwater video camera. All confidence intervals intersect 0, indicating that all variables were poor predictors of flounder abundance. Estimates were calculated using all models listed in Table 4 and included a 0 for variables not present in a particular model (Burnham and Anderson 2002).

	Mean parameter	95% Confidence interval	
Variable	estimate	Lower	Upper
Burrows	0.009	-0.285	0.303
Tubes	-0.001	-0.098	0.096
State (block)	0.003	-0.065	0.071
Bedforms	0.026	-0.061	0.114
Biogenic structure	-0.001	-0.025	0.024
Shell hash (25-75%)	0.018	-0.078	0.113
Sediment	0.019	-0.046	0.084

Table 7. Models used to compare flounder abundance (transformed CPUE) to habitat variables measured with the sediment profiling camera. All models included an intercept. Log likelihood is the value of the maximized log-likelihood function, k is the number of parameters estimated in the model (including the intercept and mean-square error), AIC_c is Akaike's Information Criterion corrected for small sample size, Δ_i is the difference between the model with the lowest AIC_c and the given model, and w_i is the Akaike weight for the model indicating the evidence for the model relative to others in the set.

Model	Log likelihood	*k*	AIC_c	Δ_i	w_i
Burrows	-34.200	3	75.444	0.000	0.205
Burrows + Infauna	-32.917	4	75.651	0.207	0.185
Burrows + Clasts/Mounds	-33.151	4	76.120	0.676	0.146
Infauna	-35.113	3	77.269	1.825	0.082
Clasts/Mounds	-35.249	3	77.541	2.097	0.072
Infauna + Clasts/Mounds	-34.009	4	77.836	2.392	0.062
Burrows + Infauna + Burrows*Infauna	-32.515	5	77.886	2.442	0.061
Burrows + Infauna + Clasts/Mounds	-32.544	5	77.945	2.501	0.059
Burrows + Clasts/Mounds + Burrows*Clasts/Mounds	-33.129	5	79.115	3.671	0.033
Small tubes	-36.167	3	79.377	3.933	0.029
Infauna + Clasts/Mounds + Infauna*Clasts/Mounds	-33.530	5	79.917	4.473	0.022
Shell	-36.725	3	80.493	5.049	0.016
Oxic voids	-37.223	3	81.490	6.046	0.010
Intercept only	-39.128	2	82.756	7.312	0.005
Pellets	-38.253	3	83.550	8.106	0.004
Dark mineral	-38.429	3	83.902	8.458	0.003
Large tubes	-38.629	3	84.301	8.857	0.002
Bedforms	-38.899	3	84.842	9.398	0.002
State (Block)	-39.063	3	85.170	9.726	0.002
All variables listed + intercept (no interactions)	-18.311	13	90.621	15.177	0.000

Table 8. Model-averaged estimates of effect size and approximate 95% confidence intervals for variables used to predict flounder abundance along trawl lines with the sediment-profiling camera. All confidence intervals intersect 0, indicating that all variables were poor predictors of flounder abundance. Estimates were calculated using all models listed in Table 6 and included a 0 for variables not present in a particular model (Burnham and Anderson 2002).

Variable	Mean parameter estimate	95% Confidence interval Lower	Upper
Burrows	0.089	-0.695	0.873
Infauna	0.328	-1.210	1.866
Clasts/Mounds	0.045	-0.516	0.606
Small tubes	0.010	-0.240	0.259
Shell	0.022	-0.285	0.329
Oxic voids	0.025	-0.341	0.391
Pellets	-0.020	-0.310	0.270
Dark mineral	-0.003	-0.117	0.111
Large tubes	0.012	-0.212	0.236
Bedforms	0.006	-0.150	0.162
State (block)	-0.070	-0.604	0.463

Table 9. Models used to compare windowpane abundance (transformed CPUE) to habitat variables measured with the sediment profiling camera. All models included an intercept. Log likelihood is the value of the maximized log-likelihood function, k is the number of parameters estimated in the model (including the intercept and mean-square error), AIC_c is Akaike's Information Criterion corrected for small sample size, Δ_i is the difference between the model with the lowest AIC_c and the given model, and w_i is the Akaike weight for the model indicating the evidence for the model relative to others in the set.

Model	Log likelihood	k	AIC_c	Δ_i	w_i
Oxic voids + Clasts/mounds + Oxic voids*Clasts/mounds	7.945	5	-3.032	0.000	0.690
Clastsmounds	3.262	3	0.520	3.552	0.117
Oxic voids	3.078	3	0.887	3.919	0.097
Clasts/mounds + Oxic voids	4.063	4	1.691	4.723	0.065
Shell	0.480	3	6.084	9.116	0.007
Burrows	0.474	3	6.095	9.127	0.007
Infauna	0.354	3	6.335	9.367	0.006
Small tubes	0.151	3	6.742	9.774	0.005
Intercept only	-2.299	2	9.099	12.131	0.002
Bedforms	-1.523	3	10.089	13.120	0.001
State (block)	-1.774	3	10.591	13.623	0.001
Large tubes	-2.195	3	11.433	14.465	0.000
Pellets	-2.224	3	11.491	14.523	0.000
Dark Minerals	-2.299	3	11.642	14.674	0.000
All variables listed + intercept (no interactions)	15.981	13	22.038	25.070	0.000

Table 10. Model-averaged estimates of effect size and approximate 95% confidence intervals for variables used to predict windowpane abundance along trawl lines with the sediment-profiling camera. All confidence intervals intersect 0, indicating that all variables were poor predictors of flounder abundance. Estimates were calculated using all models listed in Table 8 and included a 0 for variables not present in a particular model (Burnham and Anderson 2002).

Variable	Mean parameter estimate	95% Confidence interval Lower	Upper
Oxic voids	0.150	0.014	0.286
Clasts/mounds	0.011	-0.026	0.048
Shell	0.006	-0.031	0.043
Burrows	0.009	-0.041	0.058
Infauna	0.003	-0.084	0.089
Small tubes	0.006	-0.034	0.046
Bedforms	0.002	-0.016	0.020
Large tubes	0.002	-0.014	0.018
Pellets	-0.008	-0.040	0.024
Dark Minerals	0.001	-0.014	0.016
State (block)	-0.012	-0.056	0.032

Table 11. Models used to productive versus unproductive fishing areas based on to habitat variables measured with the underwater video camera. All models included an intercept. Log likelihood is the value of the maximized log-likelihood function, k is the number of parameters estimated in the model (including the intercept and mean-square error), AIC_c is Akaike's Information Criterion corrected for small sample size, Δ_i is the difference between the model with the lowest AIC_c and the given model, and w_i is the Akaike weight for the model indicating the evidence for the model relative to others in the set.

Model	Log likelihood	k	AIC_c	Δ_i	w_i
All variables listed + intercept (no interactions)	-46.143	8	109.770	0.000	0.816
Sediment	-55.020	2	114.157	4.387	0.091
Tubes + Sediment	-54.564	3	115.363	5.593	0.050
Sediment + Tubes + Sediment*Tubes	-54.531	4	117.459	7.689	0.017
Tubes	-57.730	2	119.576	9.806	0.006
Bedforms	-57.855	2	119.826	10.056	0.005
Biogenic structure	-57.968	2	120.052	10.282	0.005
Burrows	-57.973	2	120.062	10.292	0.005
Shell hash (25-75%)	-58.099	2	120.314	10.544	0.004
Intercept only	-73.304	1	148.646	38.876	0.000
State (block)	-73.291	2	150.698	40.928	0.000

Table 12. Model-averaged estimates of effect size and approximate 95% confidence intervals for variables used to predict productive and unproductive fishing habitat with the underwater video camera. All confidence intervals intersect 0, indicating that all variables were poor predictors of flounder abundance. Estimates were calculated using all models listed in Table 10 and included a 0 for variables not present in a particular model (Burnham and Anderson 2002).

Variable	Mean parameter estimate	95% Confidence interval Lower	Upper
Sediment	0.289	-2.024	2.602
Burrows	0.010	-0.971	0.990
Tubes	-0.014	-0.996	0.967
Biogenic structure	0.000	-0.967	0.968
Bedforms	0.240	-2.518	2.999
Shell hash (25-75%)	0.052	-2.399	2.503
State (block)	0.245	-2.665	3.154

Table 13. Average dissimilarity and percent contribution of species to separation of trawls grouped by summer flounder abundance (low vs. high) for Maryland. Shown is also the average abundance (CPUE) of species in each group, and the dissimilarity to standard deviation ratio, a measure of how well a species discriminates between the two groups of trawls (the larger the ratio, the better).

Maryland

Species	Group High Average Abundance	Group Low Average Abundance	Average Dissimilarity Mean	Average Dissimilarity SD	Percent Contribution	Cumulative Percent
Summer flounder	7.05	0.90	6.83	2.37	15.95	15.95
Clearnose skate	156.32	133.96	3.89	1.08	9.08	25.03
Bullnose ray	2.80	1.87	3.86	1.42	9.00	34.03
Southern stingray	2.06	0.27	3.50	1.08	8.17	42.20
Spotted hake	1.91	0.12	3.29	1.21	7.68	49.88
Striped searobin	0.44	1.46	2.85	1.01	6.67	56.54
Scup	2.23	0.22	2.73	0.86	6.37	62.92
Windowpane	1.24	0.57	2.62	1.29	6.12	69.04
Butterfish	0.77	0.19	2.31	1.32	5.40	74.44
Weakfish	1.84	0.00	2.13	0.63	4.98	79.42
Smooth dogfish	0.64	0.39	2.01	1.19	4.70	84.13
Winter skate	0.41	1.08	1.81	0.78	4.22	88.35
Northern kingfish	0.87	0.00	1.43	0.58	3.34	91.69

Rhode Island

Species	Group High Average Abundance	Group Low Average Abundance	Average Dissimilarity Mean	Average Dissimilarity SD	Percent Contribution	Cumulative Percent
Butterfish	116.62	41.62	10.38	1.15	15.16	15.16
Summer flounder	9.74	1.04	8.44	2.06	12.31	27.47
Scup	4.52	24.96	6.65	1.14	9.70	37.17
Winter skate	15.01	8.81	6.63	1.30	9.68	46.84
Windowpane	1.82	0.31	3.64	1.39	5.31	52.16
Blue runner	0.76	10.82	3.42	0.68	5.00	57.15
Spiny dogfish	0.45	17.41	3.41	0.68	4.97	62.13
Bluefish	0.44	1.38	3.36	0.90	4.91	67.03
Tautog	2.62	0.61	3.26	0.70	4.76	71.79
Striped searobin	1.64	0.23	3.08	0.81	4.49	76.28
Smooth dogfish	0.06	11.77	2.63	0.51	3.84	80.12
Striped bass	0.23	2.28	2.36	0.64	3.45	83.57
Black sea bass	0.44	0.76	2.28	0.87	3.32	86.89
Winter flounder	0.80	0.33	2.17	0.92	3.17	90.06

Table 14. Average dissimilarity and percent contribution of species to separation of trawls grouped by summer flounder abundance (low vs. high) for Rhode Island. Shown is also the average abundance (CPUE) of species in each group, and the dissimilarity to standard deviation ratio, a measure of how well a species discriminates between the two groups of trawls (the larger the ratio, the better).

Maryland

Species	Group High Average Abundance	Group Low Average Abundance	Average Dissimilarity		Percent Contribution	Cumulative Percent
			Mean	SD		
Summer flounder	6.08	1.33	6.01	1.92	14.26	14.26
Clearnose skate	143.75	143.36	4.02	1.11	9.53	23.78
Bullnose ray	2.46	2.10	3.76	1.34	8.93	32.71
Southern stingray	1.94	0.26	3.39	1.06	8.04	40.75
Spotted hake	1.83	0.08	3.23	1.19	7.67	48.41
Striped searobin	0.59	1.40	2.95	1.00	7.00	55.41
Scup	2.19	0.13	2.87	0.92	6.81	62.22
Windowpane	1.32	0.46	2.77	1.26	6.58	68.79
Smooth Dogfish	0.68	0.34	2.12	1.23	5.03	73.82
Winter Skate	1.43	0.24	2.11	0.74	5.00	78.82
Butterfish	0.62	0.28	2.04	1.14	4.84	83.67
Weakfish	1.69	0.00	1.97	0.60	4.68	88.35
Northern kingfish	0.81	0.00	1.32	0.55	3.14	91.49

Rhode Island

Species	Group High Average Abundance	Group Low Average Abundance	Average Dissimilarity		Percent Contribution	Cumulative Percent
			Mean	SD		
Butterfish	145.2	0.81	11.48	1.14	16.06	16.06
Summer flounder	7.88	1.08	7.51	1.65	10.51	26.57
Winter skate	13.58	8.94	6.86	1.25	9.60	36.17
Scup	3.91	29.45	6.80	1.09	9.52	45.69
Spiny dogfish	0.28	20.83	3.97	0.71	5.55	51.24
Windowpane	1.78	0.05	3.76	1.38	5.26	56.50
Bluefish	0.46	1.55	3.75	0.93	5.24	61.75
Blue runner	0.62	12.88	3.65	0.66	5.10	66.85
Smooth dogfish	0.09	14.00	3.15	0.56	4.40	71.25
Striped searobin	1.60	0.00	3.06	0.82	4.29	75.53
Tautog	2.10	0.70	3.01	0.68	4.21	79.74
Striped bass	0.18	2.71	2.76	0.69	3.86	83.60
Black sea bass	0.49	0.78	2.47	0.87	3.45	87.06
Little skate	0.13	2.05	2.35	0.49	3.29	90.35

A. Maryland

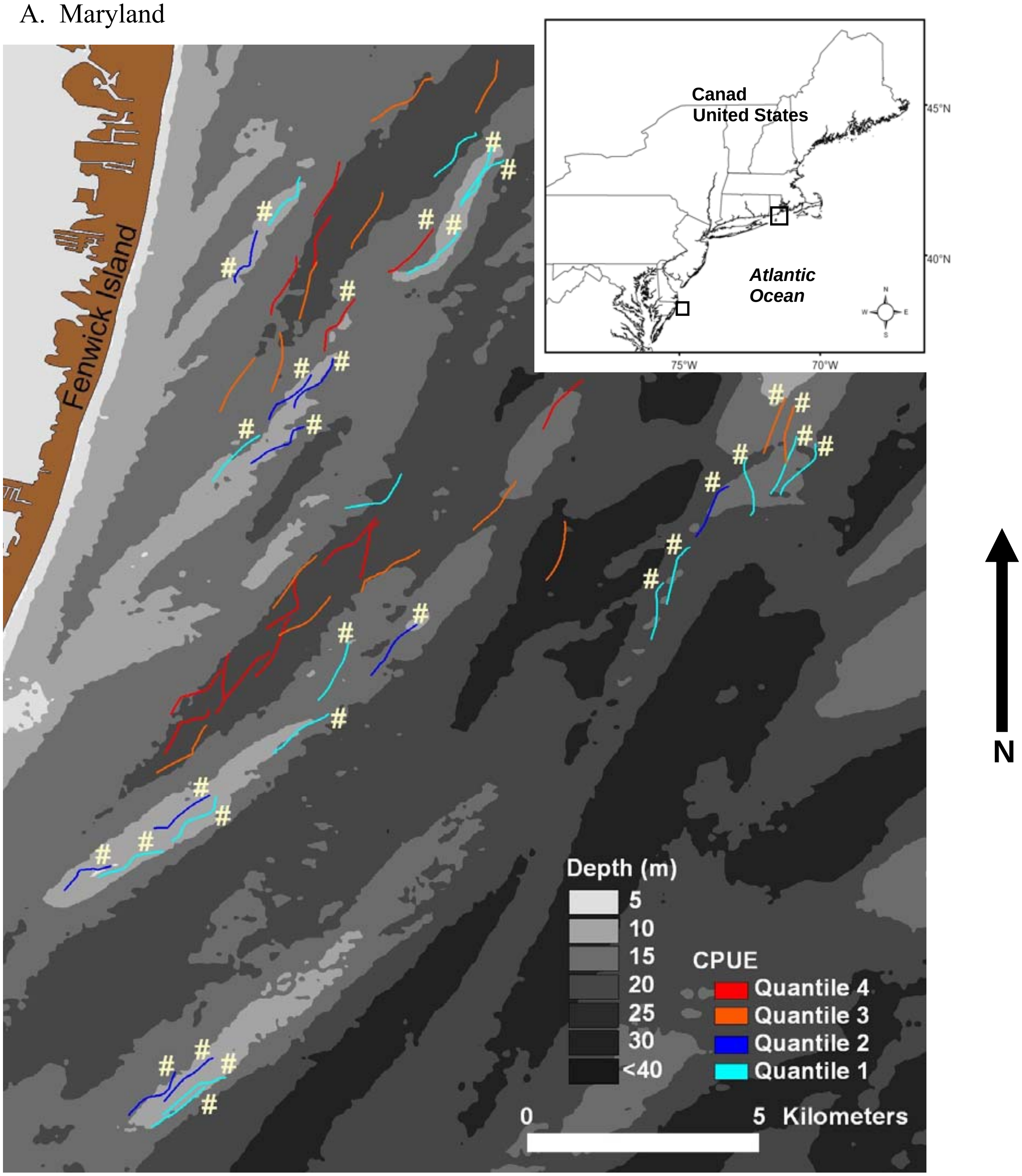
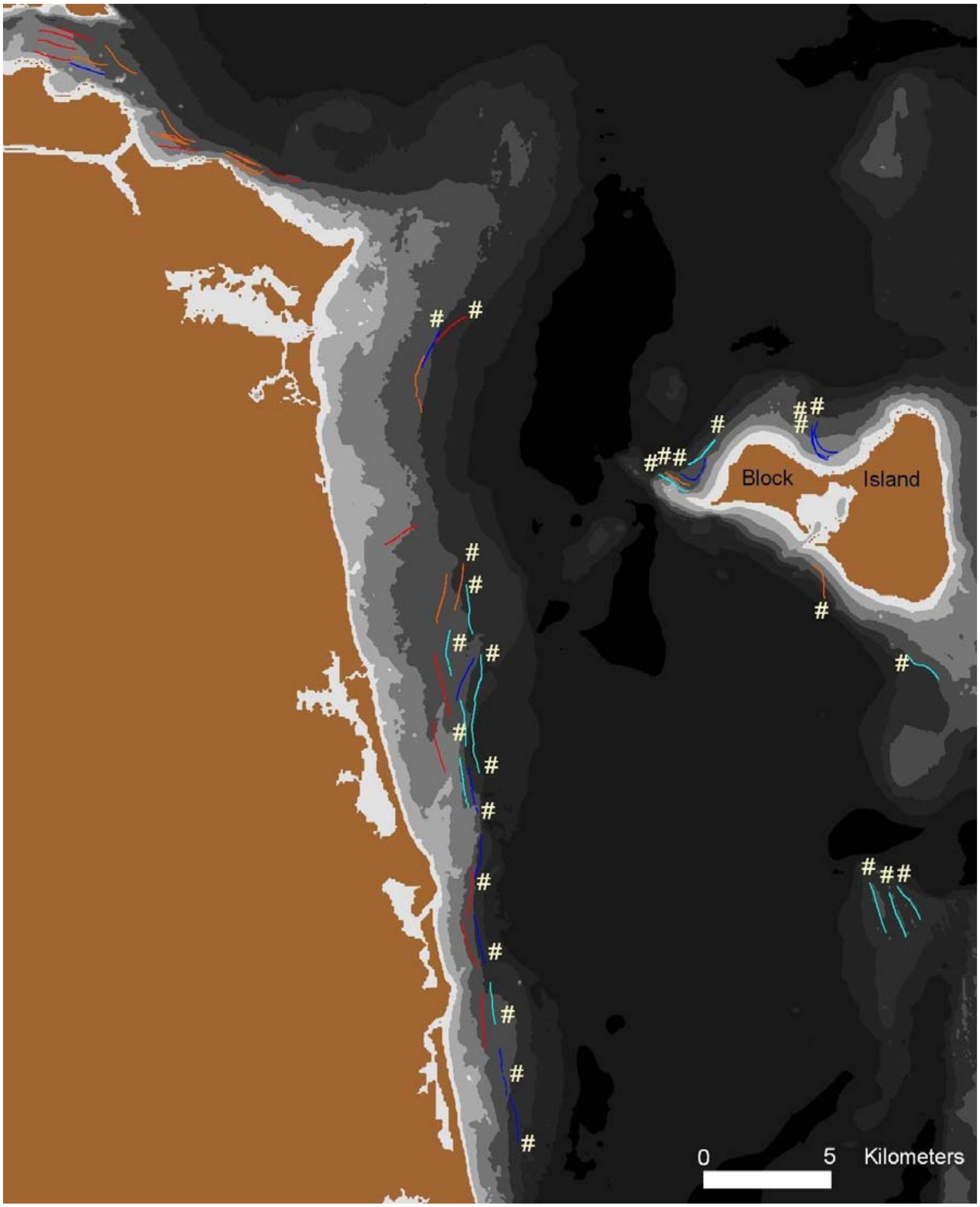


Figure 1. Map of trawls conducted off the coast of (A) Maryland or (B; following page) Rhode Island at which underwater video was collected to determine habitat requirements for summer flounder. Catch per 1,000 m towed (CPUE) is presented by quantile (e.g., trawls in the 1st quantile had catches that ranked within the 1st to 25th percentile of all catches in the state). The symbol '#' indicates trawls in unproductive areas as determined by cooperating commercial fisherman. Trawls in areas designated as productive are unlabeled. Note that map orientation and scales differ.

B. Rhode Island



Summer Flounder

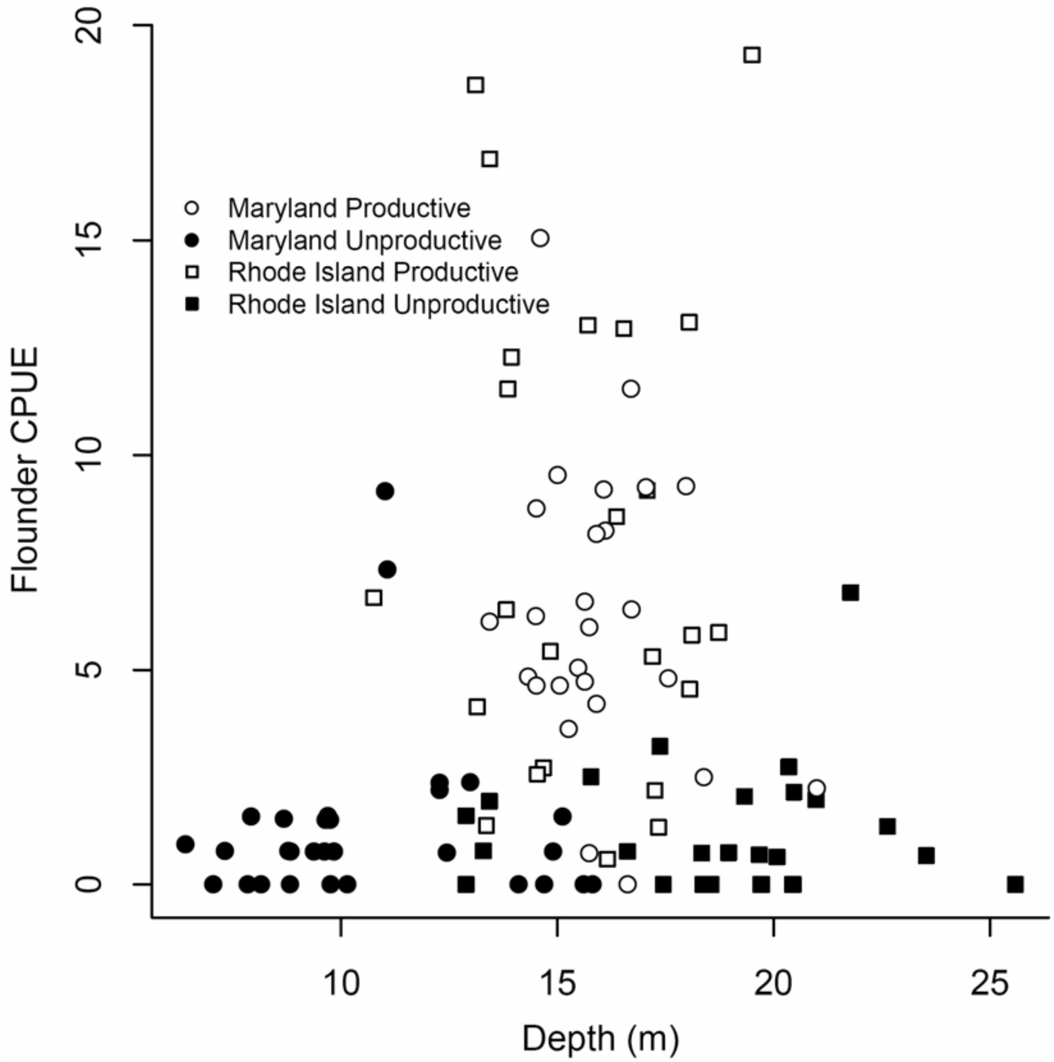


Figure 2. Number of flounder captured per 1,000 m trawled (CPUE) versus mean depth of the trawl. Trawl locations were designated *a priori* as productive or unproductive by participating fishermen. Trawls located in the Rhode Island study area are indicated by squares and trawls in the Maryland study area are indicated by circles.

Window Pane

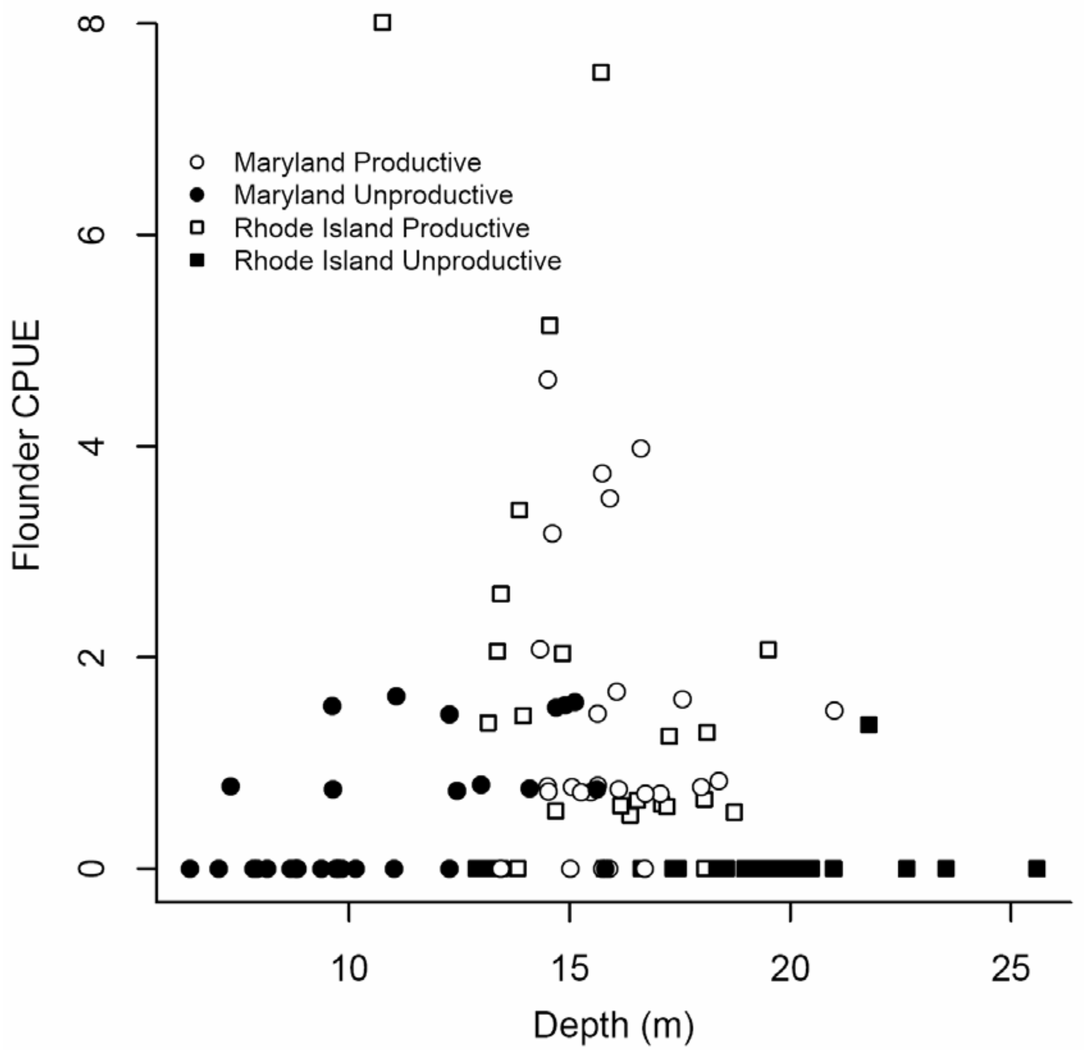
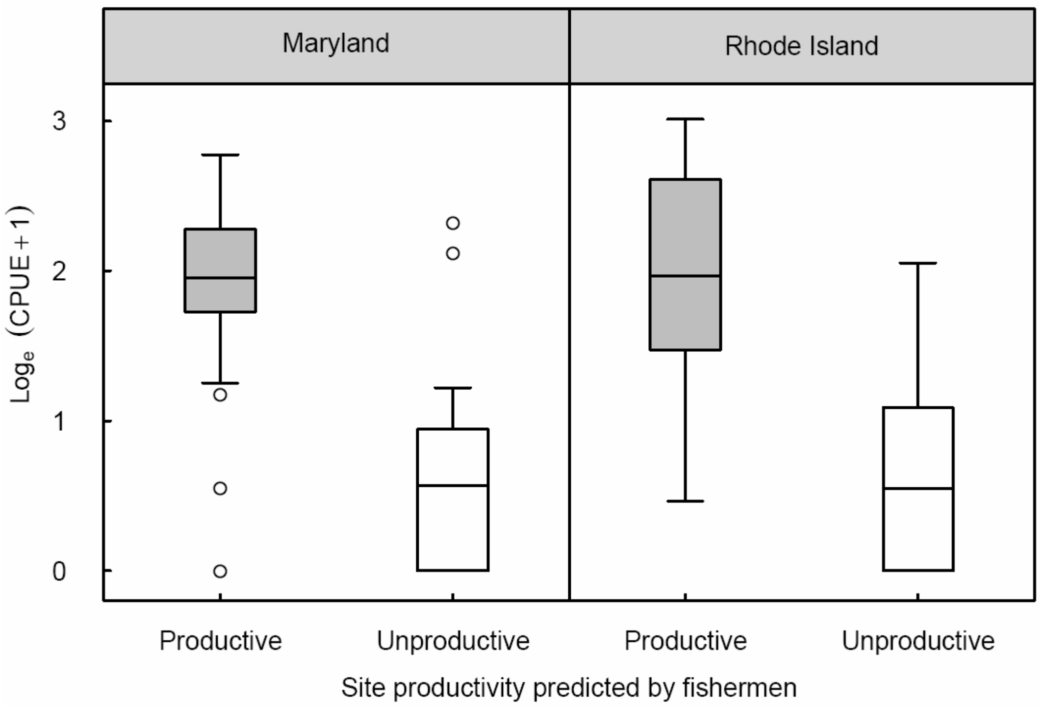


Figure 3. Number of windowpane captured per 1,000 m trawled (CPUE) versus mean depth of the trawl. Trawl locations were designated *a priori* as productive or unproductive for summer flounder by participating fishermen.

A. Summer Flounder



B. Windowpane

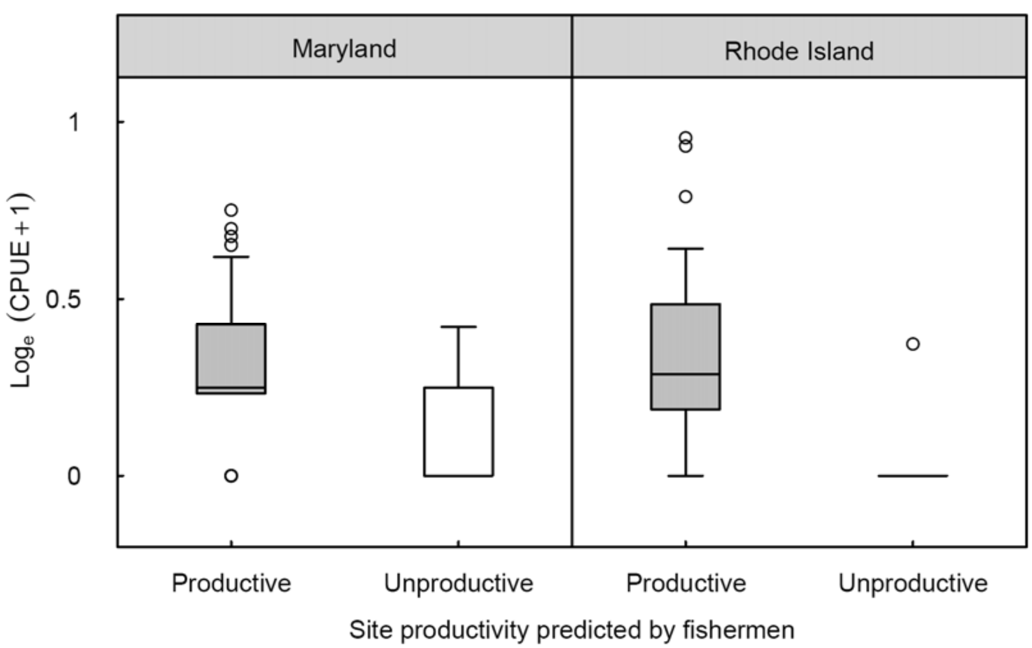


Figure 4. Distribution of trawl catches of summer flounder (A) and windowpane (B; transformed to $\log_e$[CPUE +1]) in areas that were predicted *a priori* by fishermen to be productive or unproductive in Maryland and Rhode Island study areas. Boxes indicate the 25th and 75th percentiles of the data. Center lines indicate the median. Bars indicate all other data except extreme values, which are delineated by circles.

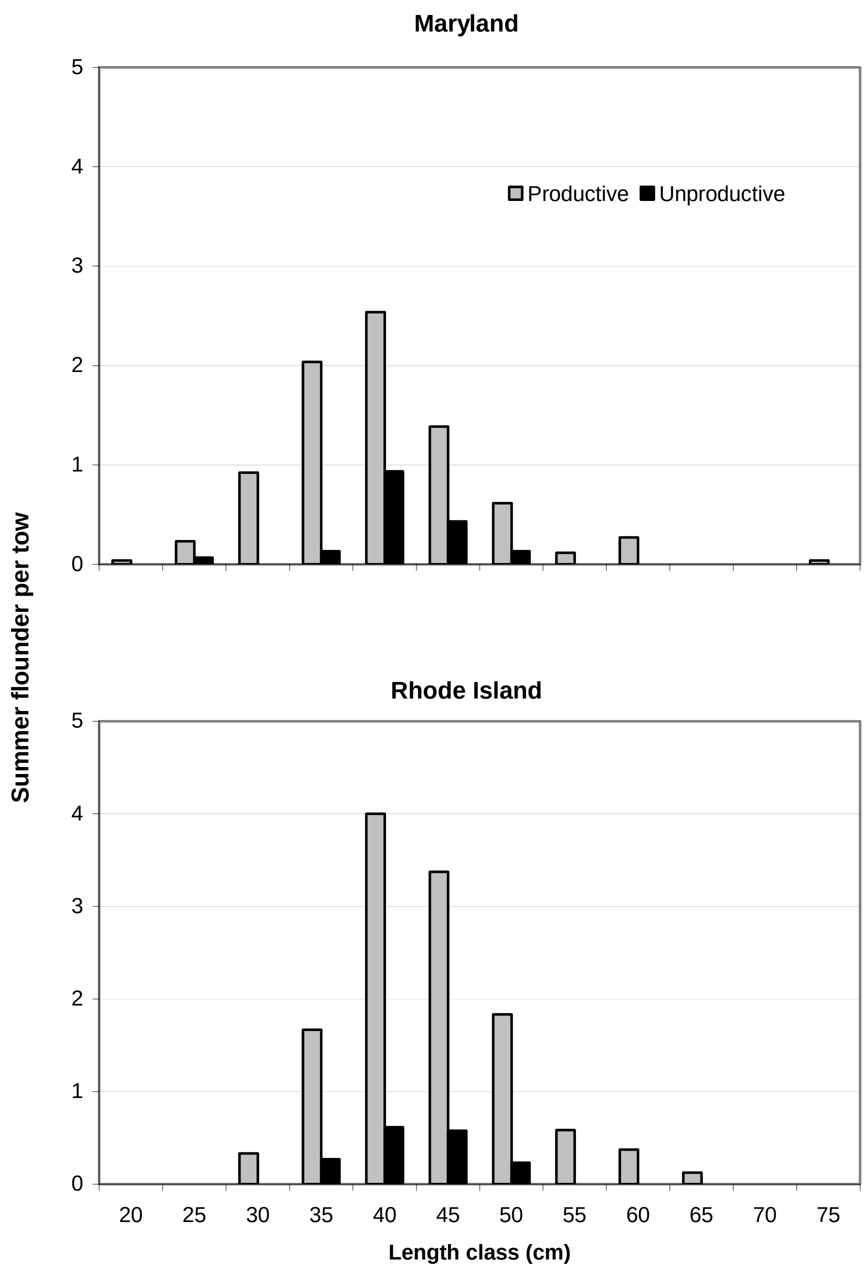


Figure 5. Mean number of summer flounder captured per tow by 5-cm length class in Maryland and Rhode Island study areas.

APPENDIX A

SUMMARIZED DATA

Table A-1. Trawl locations (decimal degrees), distances, depths, productivity predicted by fishermen, and number of summer flounder and windowpane captured.

Trawl ID Number	State	Date	Fishing Quality	Mean depth (m)	Distance trawled (m)	Flounder Captured	Windowpane Captured	Start Latitude	Start Longitude
1109-703-17-801-1	MD	6/17/2004	Productive	15.9	1426	6	5	38.3034	-75.0441
1109-703-17-802-1	MD	6/17/2004	Productive	17.1	1406	13	1	38.3222	-75.0249
1109-703-17-803-1	MD	6/17/2004	Productive	16.7	1405	9	1	38.3436	-75.0119
1109-703-17-804-1	MD	6/17/2004	Productive	18.0	1293	12	1	38.3521	-75.0010
1109-703-17-805-1	MD	6/17/2004	Productive	17.6	1246	6	2	38.3378	-75.0104
1109-703-17-806-1	MD	6/17/2004	Productive	16.7	1299	15	0	38.3270	-75.0223
1109-703-17-807-1	MD	6/17/2004	Productive	15.6	1365	9	2	38.3156	-75.0340
1109-703-17-808-1	MD	6/17/2004	Productive	15.0	1362	13	0	38.3148	-75.0413
1109-703-17-809-1	MD	6/17/2004	Productive	16.1	1334	11	1	38.3314	-75.0227
1109-703-18-801-1	MD	6/18/2004	Unproductive	12.5	1356	1	1	38.3176	-75.0127
1109-703-18-802-1	MD	6/18/2004	Productive	15.5	1386	7	1	38.3387	-75.0044
1109-703-18-803-1	MD	6/18/2004	Productive	15.1	1293	6	1	38.3505	-74.9827
1109-703-18-804-1	MD	6/18/2004	Productive	14.5	1280	8	1	38.3702	-74.9692
1109-703-18-805-1	MD	6/18/2004	Unproductive	14.9	1295	1	2	38.3644	-74.9298
1109-703-18-806-1	MD	6/18/2004	Unproductive	14.1	1316	0	1	38.3575	-74.9251
1109-703-18-807-1	MD	6/18/2004	Unproductive	14.7	1311	0	2	38.3676	-74.9164
1109-703-18-808-1	MD	6/18/2004	Unproductive	15.6	1333	0	1	38.3472	-74.9408
1109-703-18-809-1	MD	6/18/2004	Unproductive	12.3	1366	3	2	38.3322	-74.9937
1109-703-18-810-1	MD	6/18/2004	Unproductive	10.2	1293	0	0	38.3149	-75.0109
1109-703-18-811-1	MD	6/18/2004	Productive	15.9	1347	11	0	38.3149	-75.0494
1109-703-22-801-1	MD	6/22/2004	Productive	13.4	1305	8	0	38.3736	-75.0318
1109-703-22-802-1	MD	6/22/2004	Productive	14.5	1370	12	1	38.3923	-75.0219
1109-703-22-803-1	MD	6/22/2004	Productive	14.6	1262	19	4	38.4116	-75.0135
1109-703-22-804-1	MD	6/22/2004	Productive	14.3	1446	7	3	38.4298	-75.0025
1109-703-22-805-1	MD	6/22/2004	Productive	18.4	1201	3	1	38.4417	-74.9781
1109-703-22-806-1	MD	6/22/2004	Productive	16.6	1255	0	5	38.4276	-74.9823
1109-703-22-807-1	MD	6/22/2004	Productive	15.7	1336	8	5	38.4161	-75.0003
1109-703-22-808-1	MD	6/22/2004	Productive	16.1	1195	11	2	38.4114	-75.0104
1109-703-22-809-1	MD	6/22/2004	Productive	15.6	1272	6	1	38.4026	-75.0132
1109-703-22-810-1	MD	6/22/2004	Productive	14.5	1296	6	6	38.3889	-75.0202
1109-703-25-801-1	MD	6/25/2004	Unproductive	9.6	1298	1	2	38.3624	-75.0416
1109-703-25-802-1	MD	6/25/2004	Unproductive	9.7	1252	2	0	38.3745	-75.0307
1109-703-25-803-1	MD	6/25/2004	Unproductive	11.0	1309	12	0	38.3877	-75.0199
1109-703-25-804-1	MD	6/25/2004	Unproductive	11.1	1227	9	2	38.4031	-75.0075
1109-703-25-805-1	MD	6/25/2004	Unproductive	8.8	1290	1	0	38.4168	-74.9932
1109-703-25-809-1	MD	6/25/2004	Unproductive	9.8	1304	1	0	38.4248	-74.9852
1109-703-25-810-1	MD	6/25/2004	Unproductive	9.4	1302	1	0	38.4108	-74.9940
1109-703-25-811-1	MD	6/25/2004	Unproductive	8.8	1263	0	0	38.4214	-75.0247
1109-703-25-812-1	MD	6/25/2004	Unproductive	8.8	1287	1	0	38.4110	-75.0330
1109-703-25-813-1	MD	6/25/2004	Unproductive	9.8	1324	2	0	38.3863	-75.0183
1109-703-25-814-1	MD	6/25/2004	Unproductive	8.7	1307	2	0	38.3731	-75.0239

Table A-1. Continued

Trawl ID Number	State	Date	Fishing Quality	Mean depth (m)	Distance trawled (m)	Flounder Captured	Windowpane Captured	Start Latitude	Start Longitude
1109-703-26-801-1	MD	6/26/2004	Unproductive	7.3	1285	1	1	38.2508	-75.0415
1109-703-26-802-1	MD	6/26/2004	Unproductive	9.8	1266	0	0	38.2375	-75.0532
1109-703-26-803-1	MD	6/26/2004	Unproductive	8.2	1413	0	0	38.2471	-75.0391
1109-703-26-804-1	MD	6/26/2004	Unproductive	9.6	1330	2	1	38.2397	-75.0577
1109-703-26-805-1	MD	6/26/2004	Unproductive	7.1	1337	0	0	38.2855	-75.0637
1109-703-26-806-1	MD	6/26/2004	Unproductive	7.8	1350	0	0	38.2927	-75.0493
1109-703-26-807-1	MD	6/26/2004	Unproductive	7.9	1264	2	0	38.3016	-75.0422
1109-703-26-808-1	MD	6/26/2004	Unproductive	6.4	1071	1	0	38.2878	-75.0614
1109-703-30-801-1	MD	6/30/2004	Productive	15.3	1377	5	1	38.3378	-75.1799
1109-703-30-802-1	MD	6/30/2004	Productive	15.7	1369	1	0	38.3572	-75.0156
1109-703-30-803-1	MD	6/30/2004	Productive	21.0	1337	3	2	38.3547	-74.9734
1109-703-30-804-1	MD	6/30/2004	Unproductive	15.8	1273	0	0	35.3316	-74.9566
1109-703-30-805-1	MD	6/30/2004	Unproductive	15.1	1268	2	2	38.3514	-74.9481
1109-703-30-806-1	MD	6/30/2004	Unproductive	12.3	1266	3	0	38.3678	-74.9348
1109-703-30-807-1	MD	6/30/2004	Unproductive	13.0	1256	3	1	38.3780	-74.9286
1109-703-02-801-2	RI	8/2/2004	Productive	16.4	1984	17	1	41.3240	-71.6152
1109-703-02-802-2	RI	8/2/2004	Productive	16.2	1683	1	1	41.3223	-71.6684
1109-703-02-803-2	RI	8/2/2004	Productive	18.1	1528	20	1	41.3176	-71.7087
1109-703-02-804-2	RI	8/2/2004	Productive	17.1	1634	15	1	41.3143	-71.7539
1109-703-02-805-2	RI	8/2/2004	Productive	16.5	1546	20	1	41.3156	-71.7442
1109-703-02-806-2	RI	8/2/2004	Productive	13.1	1612	30	0	41.3276	-71.6733
1109-703-02-807-2	RI	8/2/2004	Productive	17.3	1505	2	0	41.3237	-71.6472
1109-703-02-808-2	RI	8/2/2004	Productive	18.1	1538	7	0	41.3305	-71.6201
1109-703-02-809-2	RI	8/2/2004	Productive	13.9	1384	17	2	41.3496	-71.6079
1109-703-02-810-2	RI	8/2/2004	Productive	18.7	1873	11	1	41.3361	-71.5435
1109-703-03-801-2	RI	8/3/2004	Unproductive	12.9	1281	0	0	41.2506	-71.5663
1109-703-03-802-2	RI	8/3/2004	Unproductive	15.8	1195	3	0	41.2481	-71.5655
1109-703-03-803-2	RI	8/3/2004	Unproductive	16.6	1291	1	0	41.2426	-74.5658
1109-703-03-804-2	RI	8/3/2004	Unproductive	18.6	1341	0	0	41.2398	-71.5624
1109-703-03-805-2	RI	8/3/2004	Unproductive	13.4	1543	3	0	41.1934	-71.5471
1109-703-03-806-2	RI	8/3/2004	Unproductive	12.9	1248	2	0	41.1895	-71.5596
1109-703-03-807-2	RI	8/3/2004	Unproductive	13.3	1286	1	0	41.1945	-71.5497
1109-703-03-808-2	RI	8/3/2004	Unproductive	17.4	1243	4	0	41.1951	-71.5990
1109-703-03-809-2	RI	8/3/2004	Unproductive	19.7	1485	0	0	41.1611	-71.6315
1109-703-03-810-2	RI	8/3/2004	Unproductive	20.5	1401	0	0	41.1564	-71.7266
1109-703-03-811-2	RI	8/3/2004	Unproductive	20.4	1518	0	0	41.1675	-71.7170
1109-703-03-812-2	RI	8/3/2004	Unproductive	19.7	1679	0	0	41.1687	-71.7313
1109-703-04-801-2	RI	8/4/2004	Productive	19.5	1450	28	3	41.3793	-71.4603
1109-703-04-802-2	RI	8/4/2004	Productive	13.2	1451	6	2	41.3931	-71.4569
1109-703-04-803-2	RI	8/4/2004	Productive	14.8	1473	8	3	41.3950	-71.4567
1109-703-04-804-2	RI	8/4/2004	Productive	17.3	3193	7	4	41.4064	-71.4496
1109-703-04-805-2	RI	8/4/2004	Productive	13.8	1562	10	0	41.4170	-71.4495
1109-703-04-806-2	RI	8/4/2004	Productive	14.7	3675	10	2	41.4335	-71.4430
1109-703-04-807-2	RI	8/4/2004	Productive	17.2	1694	9	1	41.4177	-71.4461

Table A-1. Continued

Trawl ID Number	State	Date	Fishing Quality	Mean depth (m)	Distance trawled (m)	Flounder Captured	Windowpane Captured	Start Latitude	Start Longitude
1109-703-04-808-2	RI	8/4/2004	Productive	18.1	1548	9	2	41.4387	-71.4212
1109-703-04-809-2	RI	8/4/2004	Productive	13.4	1461	2	3	41.4496	-71.4219
1109-703-04-810-2	RI	8/4/2004	Productive	10.8	1497	10	12	41.4624	-71.4167
1109-703-04-811-2	RI	8/4/2004	Productive	13.4	1540	26	4	41.4742	-71.4093
1109-703-04-812-2	RI	8/4/2004	Productive	14.5	1556	4	8	41.4491	-71.4181
1109-703-04-813-2	RI	8/4/2004	Productive	13.9	1473	17	5	41.4746	-71.4059
1109-703-04-814-2	RI	8/4/2004	Productive	15.7	1459	19	11	41.4673	-71.4052
1109-703-06-801-2	RI	8/6/2004	Unproductive	21.8	1470	10	2	41.3200	-71.5092
1109-703-06-802-2	RI	8/6/2004	Unproductive	19.3	1466	3	0	41.3361	-71.5278
1109-703-06-803-2	RI	8/6/2004	Unproductive	20.4	1460	4	0	41.3210	-71.5980
1109-703-06-805-2	RI	8/6/2004	Unproductive	19.7	1447	1	0	41.3222	-71.6472
1109-703-06-806-2	RI	8/6/2004	Unproductive	19.0	1347	1	0	41.3192	-71.6713
1109-703-06-807-2	RI	8/6/2004	Unproductive	20.5	1393	3	0	41.3147	-71.6959
1109-703-06-808-2	RI	8/6/2004	Unproductive	21.0	1520	3	0	41.3172	-71.7250
1109-703-06-809-2	RI	8/6/2004	Unproductive	22.6	1482	2	0	41.3013	-71.8072
1109-703-06-810-2	RI	8/6/2004	Unproductive	18.3	1373	1	0	41.3054	-71.7898
1109-703-06-811-2	RI	8/6/2004	Unproductive	18.4	1299	0	0	41.3093	-71.7650
1109-703-06-812-2	RI	8/6/2004	Unproductive	25.6	2206	0	0	41.3153	-71.6740
1109-703-06-813-2	RI	8/6/2004	Unproductive	23.5	1485	1	0	41.3169	-71.6486
1109-703-06-814-2	RI	8/6/2004	Unproductive	20.1	1559	1	0	41.3176	-71.6239
1109-703-06-804-2	RI	8/8/2004	Unproductive	17.5	1472	0	0	41.3258	-71.6219

Table A-2. Mean or proportion of samples that had benthic habitat characteristics as measured using the video camera along trawls. Characteristics are described in Table A-1.

Trawl ID Number	Number of samples	Sand (100%)	Bedforms	Bedform sharpness	Bedform Size	Bedform Shape	Bedform Ripples	Biogenics	Shell hash (>= 5%)	Shell hash (>=25%)	Whole shells	Burrows	Tubes
1109-703-02-801-2	12	0.58	1.00	1.00	0.00	1.00	0.00	3.33	0.25	0.00	0.08	0.08	3.25
1109-703-02-802-2	14	0.86	0.64	0.43	0.00	0.64	0.00	7.57	0.36	0.14	0.36	2.79	4.71
1109-703-02-803-2													
1109-703-02-804-2	9	1.00	0.00	0.00	0.00	0.00	0.00	24.44	0.78	0.44	0.22	1.56	22.89
1109-703-02-805-2	9	1.00	0.44	0.44	0.00	0.44	0.00	5.11	1.00	0.44	0.00	2.22	2.89
1109-703-02-806-2	9	0.44	1.00	1.00	0.00	1.00	0.00	1.78	0.67	0.11	0.11	0.11	1.67
1109-703-02-807-2	8	0.50	0.00	0.00	0.00	0.00	0.00	18.00	0.63	0.13	0.38	0.50	17.50
1109-703-02-808-2	7	0.71	0.14	0.14	0.00	0.14	0.00	5.86	0.29	0.00	0.00	5.71	0.00
1109-703-02-809-2	10	0.10	0.70	0.70	0.00	0.00	0.00	1.50	0.60	0.00	0.10	1.50	0.00
1109-703-02-810-2	13	0.08	1.00	0.00	1.00	1.00	0.00	1.46	1.00	0.38	0.00	0.46	0.62
1109-703-03-801-2	9	0.67	0.33	0.00	0.00	0.33	0.00	0.89	0.78	0.67	0.00	0.89	0.00
1109-703-03-802-2	5	0.80	0.80	0.00	0.00	0.80	0.00	1.20	0.80	0.20	0.00	1.20	0.00
1109-703-03-803-2	11	1.00	0.00	0.00	0.00	0.00	0.00	27.73	0.27	0.00	0.00	0.45	27.27
1109-703-03-804-2	10	1.00	0.20	0.00	0.00	0.20	0.00	10.10	0.80	0.10	0.10	0.00	10.10
1109-703-03-805-2	10	1.00	0.90	0.90	0.00	0.90	0.00	25.30	0.20	0.10	0.10	0.00	25.10
1109-703-03-806-2	10	1.00	0.90	0.90	0.00	0.90	0.00	25.30	0.20	0.10	0.10	0.00	25.10
1109-703-03-807-2	7	0.86	0.86	0.86	0.00	0.86	0.00	14.29	0.71	0.14	0.00	0.00	14.29
1109-703-03-808-2	9	1.00	1.00	0.00	0.00	1.00	0.00	7.89	0.00	0.00	0.00	0.00	3.00
1109-703-03-809-2													
1109-703-03-810-2													
1109-703-03-811-2													
1109-703-03-812-2	5	1.00	0.60	0.00	0.00	0.60	0.00	4.40	0.00	0.00	0.00	0.20	1.80
1109-703-04-801-2	7	1.00	0.71	0.71	0.00	0.71	0.00	11.14	1.00	0.14	0.00	1.86	9.29
1109-703-04-802-2	7	1.00	1.00	1.00	0.00	1.00	0.00	12.86	0.71	0.00	0.00	2.29	10.57
1109-703-04-803-2	9	1.00	1.00	1.00	0.00	1.00	0.00	14.22	0.33	0.11	0.00	1.22	12.89
1109-703-04-804-2	8	1.00	1.00	1.00	0.00	0.88	0.00	35.13	0.00	0.00	0.00	1.13	33.88
1109-703-04-805-2	11	1.00	1.00	1.00	0.00	1.00	0.00	13.64	0.55	0.00	0.09	0.45	13.09
1109-703-04-806-2	8	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-04-807-2	11	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A-2. Continued

Trawl ID Number	Number of samples	Sand (100%)	Bedforms	Bedform sharpness	Bedform Size	Bedform Shape	Bedform Ripples	Biogenics	Shell hash (>= 5%)	Shell hash (>=25%)	Whole shells	Burrows	Tubes
1109-703-04-808-2	8	1.00	1.00	1.00	0.00	0.63	0.00	15.75	0.13	0.00	0.00	1.25	14.25
1109-703-04-809-2	9	1.00	1.00	1.00	0.00	1.00	0.00	18.44	0.22	0.00	0.00	0.11	18.11
1109-703-04-810-2	8	1.00	0.00	0.00	0.00	0.00	0.00	1.13	0.63	0.38	0.50	0.38	0.75
1109-703-04-811-2	9	1.00	0.11	0.00	0.00	0.11	0.00	5.56	0.89	0.67	0.89	4.00	0.00
1109-703-04-812-2	9	1.00	1.00	0.89	0.00	1.00	0.00	15.11	0.00	0.00	0.11	0.89	13.00
1109-703-04-813-2	7	1.00	0.00	0.00	0.00	0.00	0.00	26.00	0.86	0.00	0.29	24.86	0.00
1109-703-04-814-2	10	1.00	0.30	0.30	0.00	0.30	0.00	11.40	0.20	0.00	0.00	9.10	0.60
1109-703-06-801-2	4	1.00	0.00	0.00	0.00	0.00	0.00	61.25	0.00	0.00	0.75	12.50	48.75
1109-703-06-802-2	9	0.44	0.89	0.00	0.44	0.78	0.00	19.00	0.78	0.44	0.00	0.56	18.44
1109-703-06-803-2	8	0.38	0.00	0.00	0.00	0.00	0.00	5.25	0.75	0.13	0.00	2.75	2.50
1109-703-06-804-2	7	0.29	0.71	0.00	0.00	0.71	0.00	1.14	0.71	0.00	0.00	0.29	0.71
1109-703-06-805-2	9	0.78	0.00	0.00	0.00	0.00	0.00	37.33	0.44	0.11	0.33	2.22	35.11
1109-703-06-806-2	8	1.00	0.00	0.00	0.00	0.00	0.00	43.25	0.25	0.13	0.50	1.75	40.88
1109-703-06-807-2	8	1.00	0.00	0.00	0.00	0.00	0.00	5.38	1.00	0.25	0.00	4.38	1.00
1109-703-06-808-2	9	1.00	0.00	0.00	0.00	0.00	0.00	6.44	0.00	0.00	0.00	2.67	2.56
1109-703-06-809-2													
1109-703-06-810-2	10	0.40	0.00	0.00	0.00	0.00	0.00	27.00	0.80	0.50	0.30	1.30	25.70
1109-703-06-811-2	8	1.00	0.00	0.00	0.00	0.00	0.00	44.00	0.88	0.75	0.88	0.25	43.75
1109-703-06-812-2	14	1.00	0.00	0.00	0.00	0.00	0.00	34.93	0.36	0.36	0.50	2.43	32.43
1109-703-06-813-2	12	1.00	0.00	0.00	0.00	0.00	0.00	22.33	1.00	0.83	1.33	5.67	16.67
1109-703-06-814-2	10	0.30	0.00	0.00	0.00	0.00	0.00	4.80	0.90	0.20	0.10	4.80	0.00
1109-703-17-801-1													
1109-703-17-802-1													
1109-703-17-803-1	14	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-17-804-1	23	1.00	1.00	1.00	0.00	1.00	0.00	0.13	0.13	0.00	0.00	0.36	0.14
1109-703-17-805-1	13	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
1109-703-17-806-1													
1109-703-17-807-1													
1109-703-17-808-1													
1109-703-17-809-1	10	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
1109-703-18-801-1	14	1.00	1.00	1.00	0.50	1.00	0.00	0.57	0.29	0.00	0.79	2.00	0.00
1109-703-18-802-1	17	1.00	1.00	1.00	0.00	1.00	0.00	0.24	0.65	0.00	0.43	0.43	0.00
1109-703-18-803-1	11	1.00	1.00	1.00	0.00	0.00	0.00	0.55	0.18	0.00	0.00	0.07	0.00

Table A-2. Continued

Trawl ID Number	Number of samples	Sand (100%)	Bedforms	Bedform sharpness	Bedform Size	Bedform Shape	Bedform Ripples	Biogenics	Shell hash (>= 5%)	Shell hash (>=25%)	Whole shells	Burrows	Tubes
1109-703-18-804-1	6	1.00	1.00	1.00	0.00	0.00	0.00	0.50	0.50	0.00	0.29	0.50	0.00
1109-703-18-805-1	10	1.00	1.00	1.00	0.00	1.00	0.00	0.70	0.00	0.00	0.00	3.21	0.00
1109-703-18-806-1	20	1.00	1.00	1.00	0.00	1.00	0.15	0.75	0.00	0.00	0.00	4.21	0.00
1109-703-18-807-1	14	1.00	1.00	1.00	0.00	1.00	0.00	0.57	0.00	0.00	0.00	3.43	0.00
1109-703-18-808-1	12	1.00	1.00	1.00	0.00	1.00	0.00	0.83	0.00	0.00	0.07	3.71	0.00
1109-703-18-809-1	12	1.00	1.00	1.00	0.67	1.00	0.33	0.50	0.33	0.00	1.79	0.79	0.00
1109-703-18-810-1	9	1.00	1.00	1.00	0.00	1.00	0.00	0.33	0.00	0.00	1.07	0.86	0.00
1109-703-18-811-1													
1109-703-22-801-1													
1109-703-22-802-1	3	1.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
1109-703-22-803-1	17	1.00	1.00	1.00	0.00	1.00	0.00	0.35	0.82	0.06	0.00	2.36	0.00
1109-703-22-804-1	13	1.00	1.00	1.00	0.00	1.00	0.00	0.31	1.00	0.00	1.07	1.71	0.00
1109-703-22-805-1													
1109-703-22-806-1													
1109-703-22-807-1													
1109-703-22-808-1													
1109-703-22-809-1													
1109-703-22-810-1	5	0.20	1.00	1.00	0.00	1.00	0.00	0.00	1.00	0.60	0.00	0.14	0.00
1109-703-25-801-1	10	0.70	1.00	1.00	1.00	0.00	0.00	0.10	0.70	0.00	0.57	0.00	0.00
1109-703-25-802-1	12	0.33	1.00	1.00	0.67	0.42	0.00	0.08	0.83	0.00	0.71	0.21	0.00
1109-703-25-803-1	13	0.31	1.00	1.00	0.85	0.23	0.00	0.31	0.85	0.00	1.36	0.21	0.00
1109-703-25-804-1	14	0.43	1.00	1.00	0.57	1.00	0.00	0.07	1.00	0.21	0.07	0.29	0.00
1109-703-25-805-1	13	1.00	1.00	1.00	0.62	1.00	0.23	0.38	0.00	0.00	0.00	0.50	0.00
1109-703-25-809-1	13	1.00	1.00	1.00	0.62	1.00	0.23	0.38	0.00	0.00	0.00	0.50	0.00
1109-703-25-810-1	17	0.59	1.00	1.00	0.88	0.29	0.18	0.47	0.71	0.06	0.86	0.57	0.00
1109-703-25-811-1													
1109-703-25-812-1	9	1.00	1.00	1.00	0.00	1.00	0.00	0.11	0.11	0.00	0.86	0.29	0.00
1109-703-25-813-1	15	1.00	1.00	1.00	0.60	1.00	0.60	0.00	0.13	0.00	0.64	0.43	0.00
1109-703-25-814-1	15	0.87	1.00	1.00	0.53	1.00	0.20	0.27	0.20	0.13	0.29	0.29	0.00
1109-703-26-801-1	10	0.80	1.00	1.00	0.30	0.70	0.70	0.60	0.30	0.10	0.86	0.50	0.00
1109-703-26-802-1	10	1.00	1.00	1.00	1.00	0.30	0.00	0.30	1.00	0.00	0.64	0.29	0.00
1109-703-26-803-1	12	1.00	1.00	1.00	0.00	1.00	0.00	0.50	0.58	0.00	1.64	1.86	0.00
1109-703-26-804-1	13	0.00	1.00	1.00	1.00	0.00	0.00	0.62	1.00	0.00	2.21	0.14	0.00

Table A-2. Continued

Trawl ID Number	Number of samples	Sand (100%)	Bedforms	Bedform sharpness	Bedform Size	Bedform Shape	Bedform Ripples	Biogenics	Shell hash (>= 5%)	Shell hash (>=25%)	Whole shells	Burrows	Tubes
1109-703-26-805-1	16	1.00	1.00	1.00	1.00	1.00	0.25	0.13	0.00	0.00	0.64	0.36	0.00
1109-703-26-806-1	11	0.91	1.00	1.00	0.18	1.00	0.00	0.09	0.73	0.00	0.50	0.00	0.00
1109-703-26-807-1	8	0.75	1.00	1.00	0.38	1.00	0.13	0.13	0.25	0.00	0.21	0.21	0.00
1109-703-26-808-1	17	0.41	1.00	1.00	1.00	0.00	0.00	0.53	0.59	0.12	0.64	0.36	0.00
1109-703-30-801-1													
1109-703-30-802-1													
1109-703-30-803-1	26	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.07	0.21
1109-703-30-804-1	8	1.00	1.00	1.00	0.00	1.00	0.38	0.50	0.00	0.00	0.14	2.21	0.00
1109-703-30-805-1	12	1.00	1.00	1.00	0.00	1.00	0.00	0.42	0.00	0.00	0.29	2.64	0.00
1109-703-30-806-1	14	1.00	1.00	1.00	0.00	1.00	0.00	0.71	0.00	0.00	0.00	1.86	0.00
1109-703-30-807-1	15	1.00	1.00	1.00	0.07	0.13	0.00	1.00	0.20	0.00	0.00	3.71	0.00

Table A-3. Mean or proportion of samples that had benthic habitat characteristics as measured using the sediment profile camera along trawls. Characteristics are described in Table A-2. Three samples were taken along each trawl near the beginning, middle, and end. Each sample consisted of ten images, which were averaged.

Trawl ID number	Shell	Dark mineral	Bedforms	Clasts/mounds	Pellets	Large tubes	Small tubes	Infauna	Burrows	Oxic voids
1109-703-25-810-1	2.00	1.33	10.00	0.00	0.33	0.00	0.67	0.00	0.00	0.00
1109-703-25-809-1	0.00	0.33	10.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00
1109-703-26-806-1	0.00	3.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-26-805-1	0.00	0.00	10.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00
1109-703-25-805-1	0.00	0.33	10.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00
1109-703-25-804-1	3.33	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-25-803-1	0.33	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-18-808-1	0.00	9.33	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1109-703-17-808-1	5.33	0.67	9.67	1.67	2.67	2.67	2.33	0.67	2.00	0.00
1109-703-22-803-1	5.33	2.67	10.00	2.67	0.67	0.33	1.33	0.33	0.33	0.00
1109-703-18-806-1	0.00	0.00	10.00	0.00	0.33	0.33	0.00	0.00	0.33	0.00
1109-703-17-806-1	0.67	2.00	6.67	3.00	1.33	4.67	3.33	0.67	3.00	0.00
1109-703-17-805-1	1.00	4.00	10.00	3.00	1.67	3.67	4.00	1.67	3.00	0.33
1109-703-17-803-1	4.00	3.33	10.00	1.00	3.00	2.33	1.67	0.33	2.33	0.00
1109-703-04-814-2	10.00	0.00	3.00	6.00	1.33	2.67	5.00	0.33	3.33	1.00
1109-703-06-812-2	8.00	3.33	0.67	3.67	1.33	7.00	2.33	0.00	0.00	0.00
1109-703-04-813-2	9.33	0.67	0.00	9.67	1.33	1.33	1.33	1.33	4.33	2.33
1109-703-04-811-2	10.00	4.00	2.00	6.00	0.67	0.00	2.33	0.67	5.00	0.33
1109-703-06-807-2	9.00	3.33	6.33	0.67	5.33	2.67	4.67	0.00	5.00	0.00
1109-703-03-807-2	3.00	0.00	9.33	5.33	2.00	5.67	0.67	0.00	0.00	0.00
1109-703-02-807-2	5.67	0.67	1.67	1.67	0.00	3.00	2.00	0.00	0.00	0.00
1109-703-04-805-2	8.00	0.33	10.00	0.67	0.67	2.67	3.00	0.00	0.00	0.00
1109-703-03-804-2	6.33	1.67	9.67	0.00	2.00	0.67	1.00	0.00	0.00	0.00
1109-703-04-803-2	5.33	0.67	10.00	0.33	0.67	7.00	7.33	0.00	0.00	0.00
1109-703-06-801-2	8.67	0.67	10.00	2.67	6.33	7.67	5.67	0.00	6.00	0.00
1109-703-04-802-2	9.00	1.33	10.00	2.67	1.67	4.33	7.00	0.00	0.00	0.00
1109-703-03-801-2	7.33	5.67	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX B

RAW DATA

Table B-1. Maryland raw data

File is attached in Excel format

(MD raw data.xls)

Table B-2. Rhode Island raw data

File is attached in Excel format

(RI raw data.xls)

Table B-3. Individual benthic sediment samples taken along trawls with the sediment profile camera.

Trawl ID number	Average grain size	Maximum grain size	Shell	Dark mineral	Bedforms	Clasts/mounds	Pellets	Large tubes	Small tubes	Infauna	Burrows	Oxic voids	Hydrobryozoans	Algae
1109-703-17-803-1	FSMS	MS	2	10	10	0	5	2	2	0	1	0		
1109-703-17-803-1	FSSI	FS	7	0	10	1	0	5	0	1	2	0		
1109-703-17-803-1	FSMS	MS	3	0	10	2	4	0	3	0	4	0		
1109-703-17-805-1	FSSI	FS	0	10	10	1	1	3	5	0	2	0		
1109-703-17-805-1	FSSI	FS	1	2	10	6	1	1	3	4	2	1		
1109-703-17-805-1	FSSI	FS	2	0	10	2	3	7	4	1	5	0		
1109-703-17-806-1	FSSI	FS	2	0	10	0	3	10	3	0	5	0		
1109-703-17-806-1	FSSI	FS	0	6	10	1	1	3	5	0	3	0		
1109-703-17-806-1	SICL	SI	0	0	0	8	0	1	2	2	1	0		
1109-703-17-808-1	FSSI	FS	2	0	9	3	2	2	3	1	2	0		
1109-703-17-808-1	FSSI	FS	6	0	10	1	3	2	1	1	3	0		
1109-703-17-808-1	FSSI	FS	8	2	10	1	3	4	3	0	1	0		
1109-703-18-806-1	FS	FS	0	0	10	0	0	1	0	0	1	0		
1109-703-18-806-1	FS	FS	0	0	10	0	0	0	0	0	0	0		
1109-703-18-806-1	FS	FS	0	0	10	0	1	0	0	0	0	0		
1109-703-18-808-1	FS	FS	0	10	10	0	0	0	0	0	0	0		
1109-703-18-808-1	FS	FS	0	8	10	0	0	0	0	0	0	0		
1109-703-18-808-1	FS	FS	0	10	10	0	0	0	0	0	0	0		
1109-703-22-803-1	FSMS	MS	2	6	10	1	2	0	0	0	0	0		
1109-703-22-803-1	FSMS	MS	7	0	10	4	0	0	2	1	1	0		
1109-703-22-803-1	FSMS	MS	7	2	10	3	0	1	2	0	0	0		
1109-703-25-803-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		
1109-703-25-803-1	FSMSCS	CS	1	0	10	0	0	0	0	0	0	0		
1109-703-25-803-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		
1109-703-25-804-1	MSCS	CS	6	0	10	0	0	0	0	0	0	0		
1109-703-25-804-1	MSCS	CS	2	0	10	0	0	0	0	0	0	0		
1109-703-25-804-1	MSCS	CS	2	0	10	0	0	0	0	0	0	0		
1109-703-25-805-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		
1109-703-25-805-1	FSMS	MS	0	1	10	0	0	0	0	0	0	0		
1109-703-25-805-1	FSMS	MS	0	0	10	0	0	0	1	0	0	0		
1109-703-25-809-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		

Table B-3. Continued

Trawl ID number	Average grain size	Maximum grain size	Shell	Dark mineral	Bedforms	Clasts/mounds	Pellets	Large tubes	Small tubes	Infauna	Burrows	Oxic voids	Hydrobryozoans	Algae
1109-703-25-809-1	FSMS	MS	0	1	10	0	0	0	0	0	0	0		
1109-703-25-809-1	FSMS	MS	0	0	10	0	0	0	1	0	0	0		
1109-703-25-810-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		
1109-703-25-810-1	FSMS	MS	1	4	10	0	1	0	1	0	0	0		
1109-703-25-810-1	MSCSGR	GR	5	0	10	0	0	0	1	0	0	0		
1109-703-26-805-1	FSMS	MS	0	0	10	0	0	0	1	0	0	0		
1109-703-26-805-1	FSMS	MS	0	0	10	0	0	0	1	0	0	0		
1109-703-26-805-1	FSMSCS	CS	0	0	10	0	0	0	0	0	0	0		
1109-703-26-806-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0		
1109-703-26-806-1	FSMS	MS	0	9	10	0	0	0	0	0	0	0		
1109-703-26-806-1	FSMS	MS	0	0	10	0	0	0	0	0	0	0	0	0
1109-703-02-807-2	CSGR	PB	5	1	0	0	0	2	2	0	0	0	2	0
1109-703-02-807-2	MSCS	GR	5	0	5	5	0	6	4	0	0	0	0	0
1109-703-02-807-2	GR	PB	7	1	0	0	0	1	0	0	0	0	0	1
1109-703-03-801-2	MSCS	CS	2	0	10	0	0	0	0	0	0	0	7	5
1109-703-03-801-2	MSCS	PB	10	10	0	0	0	0	0	0	0	0	9	3
1109-703-03-801-2	MSCS	PB	10	7	2	0	0	0	0	0	0	0	0	1
1109-703-03-804-2	MSCS	PB	5	1	9	0	0	1	0	0	0	0	0	0
1109-703-03-804-2	MSCS	CS	8	2	10	0	0	1	0	0	0	0	0	0
1109-703-03-804-2	MSCS	CS	6	2	10	0	6	0	3	0	0	0	0	0
1109-703-03-807-2	FSMS	MS	7	0	10	9	0	5	1	0	0	0	0	0
1109-703-03-807-2	FSMS	MS	0	0	10	5	0	9	0	0	0	0	2	2
1109-703-03-807-2	FSMS	CB	2	0	8	2	6	3	1	0	0	0	0	0
1109-703-04-802-2	FSMS	MS	7	0	10	2	1	7	10	0	0	0	0	0
1109-703-04-802-2	FSMS	MS	10	0	10	4	1	6	9	0	0	0	0	0
1109-703-04-802-2	FSMS	MS	10	4	10	2	3	0	2	0	0	0	0	0
1109-703-04-803-2	FSMS	MS	3	0	10	1	1	7	6	0	0	0	1	1
1109-703-04-803-2	FSMS	MS	6	2	10	0	1	6	7	0	0	0	1	0
1109-703-04-803-2	FSMS	MS	7	0	10	0	0	8	9	0	0	0	0	0
1109-703-04-805-2	FSMS	MS	10	0	10	2	0	1	1	0	0	0	0	0
1109-703-04-805-2	FSMS	MS	8	0	10	0	2	4	1	0	0	0	0	1
1109-703-04-805-2	FSMS	MS	6	1	10	0	0	3	7	0	0	0	6	1
1109-703-04-811-2	MSFSSI	PB	10	9	0	7	0	0	4	1	5	1	1	0

Table B-3. Continued

Trawl ID number	Average grain size	Maximum grain size	Shell	Dark mineral	Bedforms	Clasts/mounds	Pellets	Large tubes	Small tubes	Infauna	Burrows	Oxic voids	Hydrobryozoans	Algae
1109-703-04-811-2	MSFSSI	MS	10	3	0	8	1	0	1	1	7	0	0	0
1109-703-04-811-2	MSFSSI	MS	10	0	6	3	1	0	2	0	3	0	0	0
1109-703-04-813-2	FSSI	FS	8	0	0	10	4	0	0	1	5	3	0	0
1109-703-04-813-2	FSMSSI	MS	10	0	0	10	0	4	3	2	7	1	8	0
1109-703-04-813-2	FSMSSI	MS	10	2	0	9	0	0	1	1	1	3	0	0
1109-703-04-814-2	FSMSSI	MS	10	0	9	4	1	3	8	0	3	0	0	0
1109-703-04-814-2	FSMSSI	MS	10	0	0	8	1	1	3	0	3	1	0	0
1109-703-04-814-2	FSMSSI	MS	10	0	0	6	2	4	4	1	4	2	0	0
1109-703-06-801-2	MSCS	CS	8	0	10	0	5	6	5	0	4	0	0	0
1109-703-06-801-2	MSCS	CS	10	2	10	4	10	8	6	0	9	0	0	0
1109-703-06-801-2	MSCS	CS	8	0	10	4	4	9	6	0	5	0	4	0
1109-703-06-807-2	MSCSGRSI	PB	10	2	0	0	1	0	1	0	1	0	4	0
1109-703-06-807-2	FSMS	MS	10	3	9	0	9	4	3	0	8	0	3	0
1109-703-06-807-2	FSMS	MS	7	5	10	2	6	4	10	0	6	0	0	0
1109-703-06-812-2	FSMS	MS	9	3	1	1	1	9	3	0	0	0	0	0
1109-703-06-812-2	FSMS	MS	5	0	1	10	1	10	3	0	0	0	0	0
1109-703-06-812-2	CSGR	PB	10	7	0	0	2	2	1	0	0	0	0	0